I. PATENT ABSTRACTS OF JAPAN

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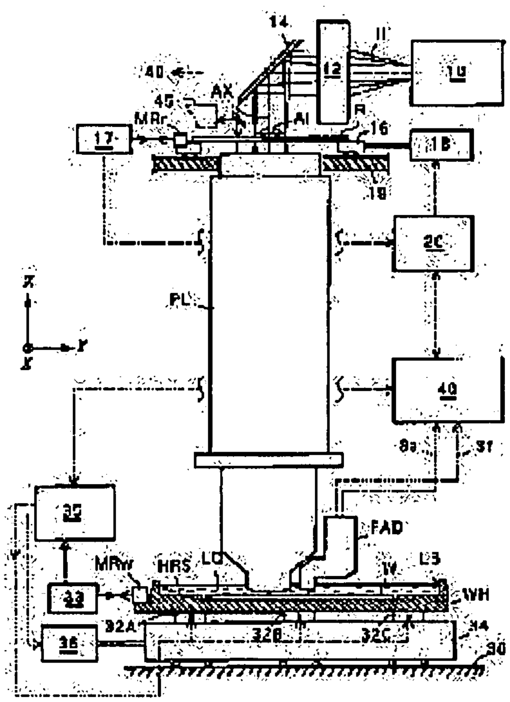
(71)Applicant : **NIKON CORP**
(72)Inventor : **USHIDA KAZUO**
SUWA KYOICHI

(54) IMMERSION ALIGNER



(57)Abstract:
PROBLEM TO BE SOLVED: To provide an immersion aligner which does not cause the deterioration of its image forming performance.
SOLUTION: An immersion aligner which is provided with a projection optical system PL which transfers a pattern Pa drawn on a reticle R to the surface of a wafer W and print-transfers the pattern Pa, and in which at least part of the working distance L between the lens surface Pe of the optical system PL closest to the wafer W and the wafer W, is filled up with a liquid LQ which transmits exposing light IL is constituted so that the working distance L may meet a relation, L ≤λ/(0.3×|N|) (where, λ and N (1/°C) respectively represent the wavelength of the light IL and the temperature coefficient of the refractive index of the liquid IQ). In addition, the liquid LQ is prepared by adding an additive which reduces the surface tension of pure water or increases the interface activity of the pure water to the pure water.

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CLAIMS

[Claim(s)]

[Claim 1] It has the projection optical system which carries out the printing imprint of the pattern drawn on reticle on a wafer. In the immersion photolithography system which filled at least the part of the working distances between the lens side which approached the wafer of this projection optical system most, and said wafer with the liquid which penetrates exposure light When the die length of said working distance is set to L, wavelength of said exposure light is set to lambda and the temperature coefficient of the refractive index of said liquid is set to N (1-/degree C), it is L<=lambda/(0.3x|N|).

The immersion photolithography system characterized by forming so that it may become.

[Claim 2] It has the projection optical system which carries out the printing imprint of the pattern drawn on reticle on a wafer. In the immersion photolithography system which filled at least the part of the working distances between the lens side which approached the wafer of this projection optical system most, and said wafer with the liquid which penetrates exposure light The immersion photolithography system characterized by using what added the additive which decreases the surface tension of pure water or increases whenever [surface activity / of pure water] as said liquid to said pure water.

[Claim 3] The immersion photolithography system according to claim 1 or 2 whose die-length L of said working distance is 2mm or less.

[Claim 4] The immersion photolithography system according to claim 1, 2, or 3 which synchronized with the velocity ratio corresponding to the scale factor of said projection optical system, and has arranged said reticle and wafer possible [a scan] to uniform velocity.

[Claim 5] The immersion photolithography system according to claim 1, 2, 3, or 4 using the light

of an ultraviolet area as said exposure light.
[Claim 6] The immersion photolithography system according to claim 1, 2, 3, 4, or 5 which formed the soffit side of the lens-barrel which forms the optical surface by the side of the wafer of the head optical element by the side of a wafer in a plane most, and holds said head optical element of said projection optical system so that the same flat surface as said optical surface might be made, and beveled to the soffit peripheral face of said lens-barrel.
[Claim 7] The immersion photolithography system according to claim 6 said whose head optical element is a parallel plate.
[Claim 8] The immersion photolithography system of claim 1-7 given in any 1 term which held said wafer on the holder table, set up the wall on the top-face periphery of said holder table so that working distance could be filled with said liquid, prepared the liquid supply unit so that said liquids could be supplied and collected in said holder table, and prepared the both sides of said holder table and a liquid supply unit the heat regulator.
[Claim 9] The immersion photolithography system of claim 1-7 given in any 1 term which attached the rise-and-fall driving gear in said pin so that said wafer is held by the wafer chuck, a wall is set up on the top-face periphery of said wafer chuck so that working distance can be filled with said liquid, said wafer chuck might be penetrated, at least three pins might be prepared and said wafer could be lifted above said wafer chuck.
[Claim 10] The immersion photolithography system of claim 1-7 given in any 1 term which attached the rise-and-fall driving gear in said wafer chuck so that said wafer is held by the wafer chuck, a wall is set up on the top-face periphery of said wafer chuck so that working distance can be filled with said liquid, said wafer chuck might be penetrated, at least three pins might be prepared and the upper bed of said wall of a wafer chuck could be made lower than the soffit of said projection optical system.
[Claim 11] The immersion photolithography system of claim 1-10 given in any 1 term which avoided interference with the soffit part of a projection optical system by preparing the fluid-tight door section which can be freely opened and closed to said a part of wall.
[Claim 12] The immersion photolithography system of claim 1-11 given in any 1 term which established the protection means so that it might be isolated from the steam which emits the flux of light which carries out incidence of the mirror for interferometers to installation and this mirror, and is reflected in the side face of said projection optical system from said liquid.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates especially to the aligner of an immersion type about the aligner which bakes the pattern drawn on reticle on a wafer according to a projection optical system.
[0002]
[Description of the Prior Art] Although spacing between the last lens side of optical system and the image surface was called working distance, the working distance of the projection optical system of the conventional aligner was filled with air. As for this working distance, it was

common to have taken 10mm or more on account of making autofocus optical system intervene etc. On the other hand, the detailed-ization is desired increasingly and it is necessary to attain short wavelength-ization of exposure wavelength for that purpose, or to aim at buildup of numerical aperture about the pattern imprinted to a wafer. However, since there is a limit in the class of glass ingredient which penetrates the light of short wavelength, the aligner of the immersion type which attains detailed-ization of an exposure pattern is proposed by filling working distance with a liquid and aiming at buildup of numerical aperture.

[0003] In the aligner of an immersion type, there is a possibility that distribution may arise in a refractive index according to the temperature distribution of the liquid made to be placed between working distances. Then, the following techniques are proposed as a cure to degradation of the image formation engine performance resulting from the temperature change of a liquid. That is, the technique indicated by drawing 3 of a U.S. Pat. No. 4,346,164 number is proposed according to the temperature stability device of a liquid (**) as what attains stabilization of temperature, and the technique indicated by JP,6-124873,A is proposed as what attains equalization of temperature by the excitation agitator style. Moreover, measuring temperature or a refractive index to JP,6-124873,A similarly as what is fed back to temperature control according to the temperature monitor device of a liquid (being) is proposed.

[0004]

[Problem(s) to be Solved by the Invention] However (**), if it sets and how many temperature is stabilized, as shown below actually, the temperature control in the precision which is hard to be referred to as realistic is needed [the argument referred to as whether it is satisfactory practically is not accomplished, but]. moreover -- (-- it is --) -- ******** -- if it takes into consideration that the temperature ununiformity of a liquid influences the image formation engine performance most, it will be hard to call it an effective cure. Thus, it was in the situation which cannot be conventionally referred to as that there is no example which mentioned the constraint about the optical parameter of a projection optical system like working distance itself in the well-known technique about an immersion photolithography system, and the special conditions of an immersion type are taken into consideration. Therefore, this invention makes easy temperature control of the liquid which fills working distance, and makes it a technical problem to offer the immersion photolithography system which does not cause degradation of the image formation engine performance.

[0005]

[Means for Solving the Problem] It is made in order that this invention may solve the above-mentioned technical problem. It has the projection optical system which carries out the printing imprint of the pattern drawn on reticle on a wafer. In the immersion photolithography system which filled at least the part of the working distances between the lens sides and wafers which approached the wafer of this projection optical system most with the liquid which penetrates exposure light When the die length of working distance is set to L, wavelength of exposure light is set to lambda and the temperature coefficient of the refractive index of a liquid is set to N (1-/degree C), it is L<=lambda/(0.3x|N|).

It is the immersion photolithography system characterized by forming so that it may become, and it is the immersion photolithography system characterized by using what added the additive which decreases the surface tension of pure water or increases whenever [surface activity / of pure water] as said liquid to pure water.

[0006] An operation of this invention is explained below. If set the distance from the glass side at the head of a projection optical system to an image formation side, i.e., working distance, to L,

width of face of the temperature distribution of the medium which fills working distance L is set to deltaT, aberration of the image formation wave front resulting from this temperature-distribution deltaT is set to deltaF and the temperature coefficient of the refractive index of a liquid is set to N, the following formulas (1) will be materialized in approximation.
deltaF=Lx|N|xdeltaT .... (1)
[0007] About temperature-distribution deltaT of a medium, in order to attain the equalization, it controls how and a way is assumed that about [deltaT=0.01 degree C] temperature distribution exist. Therefore, image formation wave aberration deltaF is deltaF=Lx|N|x0.01 at least. .... (1a)
**** exists. N is the value which expressed the temperature coefficient of a refractive index with the 1/degree-C unit here.
[0008] The values of the temperature coefficient N of a refractive index differ greatly with a liquid and a gas, for example, with air, to being N=-9x10-7/degree C, in the case of water, it is N=-8x10-5/degree C, and it has an about 100 times as many difference as this. On the other hand, although the working distance L of the projection optical system of a cutback projection aligner is usually L> 10mm, though it is L= 10mm, image formation wave aberration deltaF of the working distance is as follows.
Air: deltaF=10mmx|-9x10-7/degree-C|x0.01 degree C = 0.09nm Water : deltaF=10mmx|-8x10-5/degree-C|x0.01 degree C = 8.0nm [0009] However, generally, 1/30 or less [of the exposure wavelength lambda] is desirable, namely, image formation wave aberration deltaF is delta F<=lambda / 30. .... (2)
******(ing) is desirable. For example, deltaF<6.4nm is desirable when using an ArF excimer laser with a wavelength of 193nm as an exposure light. When the medium which fills working distance is water, by L> 10mm, it turns out like the conventional technique that the yield of the image formation wave aberration according [working distance L] to the temperature distribution of a medium is too large, and a problem is produced practically.
[0010] (1a) From a formula and (2) types to L<=lambda/(0.3x|N|) .... (3)
******. Therefore, by filling (3) types, the immersion photolithography system which carried the projection optical system by which the wave aberration yield produced according to the temperature distribution in an immersion liquid on the basis of realizable temperature stability (temperature distribution) was stopped by 1/30 or less [of exposure wavelength] is obtained. The amount of wave aberration generated because exposure light passes through the inside of the medium which had temperature distribution in this invention is easing the demand to temperature distribution by preparing the optical path length an upper limit as mentioned above paying attention to being dependent on the product of the optical path length in the amount of temperature distributions, and a medium. Practical use can be presented with an immersion photolithography system under the temperature control of the immersion liquid in level realizable by this.
[0011]
[Embodiment of the Invention] Some suitable examples for this invention are explained below.
[0012]
[Explanation of the 1st example] Drawing 1 shows the whole projection aligner configuration by the 1st example of this invention, and it shows the projection aligner of the lens scanning method which carries out the relative scan of Reticle R and the wafer W to projection lens system PL here, projecting the circuit pattern on Reticle R on the semi-conductor wafer W through cutback projection lens-system PL which has the circular image field constituted by the tele cent rucksack in the both sides by the side of a body and an image. The ArF excimer laser to which an

illumination system 10 emits pulsed light with a wavelength of 193nm in drawing 1 (un-illustrating), The beam expander which operates the cross-section configuration of the pulsed light from the light source orthopedically (un-illustrating), Optical integrators, such as a fly eye lens which carries out incidence of the pulsed light operated orthopedically, and generates secondary light source images (meeting of two or more point light sources) (un-illustrating), The condenser lens system which makes pulsed light from the secondary light source image the pulse illumination light of uniform illuminance distribution (un-illustrating), The reticle blind which operates the configuration of the pulse illumination light orthopedically in the shape of [long] a rectangle in the direction (the direction of X) which intersected perpendicularly with the scanning direction at the time of scan exposure (the direction of Y) (an illuminated viewing field diaphragm) The relay optical system (un-illustrating) for collaborating with the condenser-lens system 12 in drawing 1 and a mirror 14, and carrying out image formation of the pulsed light IL from opening of the shape of un-illustrating and a rectangle of the reticle blind on Reticle R as a lighting field A.I. Artificial Intelligence of the shape of the shape of a slit and a rectangle is included.

[0013] At the time of scan exposure, vacuum adsorption (depending on the case, they are electrostatic adsorption and machine conclusion) of the reticle R is carried out in the direction of one dimension on the movable uniform reticle stage 16 by big stroke. In drawing 1 , a reticle stage 16 is guided so that scanning migration of the column structure 19 top of the body of equipment may be carried out at the right and left in drawing (the direction of Y), and it is guided so that it may move also in the direction (the direction of X) vertical to the space of drawing. The coordinate location and minute rotation in XY flat surface of the reticle stage 16 project a laser beam on the migration mirror (a plane mirror and corner mirror) MRr attached in a part of reticle stage 16, and are serially measured by the laser interferometer system 17 which receives the reflective beam. And the reticle stage controller 20 controls the motors 18, such as a linear motor for driving a reticle stage 16 based on XY coordinate location measured by interferometer systems 17, and a voice coil, and controls migration of the scanning direction of a reticle stage 16, and migration of the non-scanning direction.

[0014] Now, if the rectangle-like pulse illumination light IL injected from the condenser-lens system 12 and the mirror 14 irradiates a part of circuit pattern space on Reticle R, the image formation flux of light from the pattern which exists in the lighting field A.I. Artificial Intelligence will let 1/4 time as many cutback projection lens system PL as this pass, and image formation projection will be carried out at the sensitive resist layer applied to the front face of Wafer W. The optical axis AX of the projection lens system PL passes along the central point of the circular image field, and it is arranged so that it may become the same axle also to each optical axis of an illumination system 10 and the condenser-lens system 12. Moreover, projection lens system PL consists of lens elements of two or more sheets made from two kinds of ** material, a quartz and a fluorite, which has high permeability to ultraviolet rays with a wavelength of 193nm, and a fluorite is used for the lens element which mainly has forward power. The interior of the lens-barrel which furthermore fixes the lens element of two or more sheets of projection lens system PL is permuted by nitrogen gas, in order to avoid absorption by the oxygen of the pulse illumination light with a wavelength of 193nm. The permutation by such nitrogen gas is similarly performed to the optical path from the interior of an illumination system 10 to the condenser-lens system 12 (or mirror 14).

[0015] By the way, Wafer W is held on the holder table WH which adsorbs the rear face. Wall LB is formed in the whole periphery section of this holder table WH in fixed height, and Liquid

LQ is filled with the predetermined depth inside this wall LB. And vacuum adsorption of the wafer W is carried out at the hollow part of the inner pars basilaris ossis occipitalis of the holder table WH. Moreover, the annular auxiliary plate section HRS which encloses the periphery of Wafer W by predetermined width of face is formed around the inner pars basilaris ossis occipitalis of the holder table WH. It is determined that the height of the front face of this auxiliary plate section HRS is mostly in agreement with the height of the front face of the standard wafer W which adsorbed on the holder table WH.

[0016] The main functions of this auxiliary plate section HRS are used as a focal detection side of an alternative of a case so that the detecting point of a focal leveling sensor may be located in the outside of the appearance edge of Wafer W. Moreover, the auxiliary plate section HRS can be used also [calibration / the calibration of the alignment sensor used when carrying out alignment of the shot field on Wafer W, and the circuit pattern on Reticle R relatively, and / of the focal leveling sensor used when carrying out scan exposure of the shot field]. However, it is more desirable to use for the calibration of an alignment sensor or a focal leveling sensor the reference mark plate of the dedication established according to the auxiliary plate section HRS and an individual. In this case, it will be attached on the holder table WH so that a reference mark plate may also become the almost same height as the projection image side of projection lens system PL in the state of immersion, and an alignment sensor will detect various kinds of reference marks formed on the reference mark plate in the state of immersion. In addition, an example of the approach of carrying out the calibration of the system offset of a focal sensor using the reference mark plate on a table is indicated by for example, the U.S. Pat. No. 4,650,983 number, and an example of the calibration approach of various alignment sensors is indicated by for example, the U.S. Pat. No. 5,243,195 number.

[0017] By the way, since the point of projection lens system PL is soaked in Liquid LQ in this example as shown in drawing 1 , the point at least has the structure where it is waterproofed and a liquid does not sink in in a lens-barrel. Furthermore, the underside (opposed face with Wafer W) of the lens element at the head of projection lens system PL is processed into a flat surface or a convex with very large radius of curvature, and, thereby, can make smooth flow of the liquid LQ produced between the underside of a lens element, and the front face of Wafer W at the time of scan exposure. Furthermore, by this example, although explained to a detail later, the best image formation side (reticle conjugation side) of projection lens system PL in an immersion condition is designed so that it may be formed in the location of about 2-1mm from the underside of the lens element at a head. Therefore, while the thickness of the liquid layer formed between the underside of the lens element at a head and the front face of Wafer W is also set to about 2-1mm and the control precision of the temperature control of Liquid LQ is eased by this, it becomes possible to also suppress generating of the temperature-distribution nonuniformity in the liquid layer.

[0018] Now, the holder table WH is attached on X-Y stage 34 so that the advancing-side-by-side migration (it moves slightly with rough migration in this example) to the Z direction in alignment with the optical axis AX of projection lens system PL and dip jogging to XY flat surface vertical to an optical axis AX may be possible. This X-Y stage 34 carries out two-dimensional migration of the base surface plate 30 top in the XY direction, and the holder table WH is attached through three actuators 32A, 32B, and 32C for Z directions on X-Y stage 34. Each actuator 32A, and B and C consist of combination devices of a piezo flexible component, a voice coil motor, a DC motor, and a lift cam etc. And if only the same amount makes a Z direction drive three Z actuators, parallel translation of the holder table WH can be carried out to

a Z direction (the direction of a focus), and if only a mutually different amount makes a Z direction drive three Z actuators, the dip (tilt) direction and amount of the holder table WH can be adjusted.
[0019] Moreover, two-dimensional migration of X-Y stage 34 is performed by the drive motor 36 which consists of linear motors which make the DC motor made to rotate a delivery screw and non-contact generate a thrust. Control of this drive motor 36 is performed by the wafer stage controller 35 which inputs the measurement coordinate location from the laser interferometer 33 which measures each location change of the direction of X of the reflector of the migration mirror MRw fixed to the edge of the holder table WH, and the direction of Y. In addition, as a whole X-Y stage 34 configuration which used the drive motor 36 as the linear motor, the configuration indicated by JP,8-233964,A, for example may be used.
[0020] Now, in this example, since the working distance of projection lens system PL is small and Liquid LQ is filled in narrow spacing of about 2-1mm between the lens element at the head of the projection lens PL, and Wafer W, it is difficult to project aslant on the wafer side corresponding to the projection visual field of projection lens system PL the floodlighting beam of the focal sensor of an oblique incidence light method. For this reason, in this example, the focal alignment sensor FAD containing the focal leveling detection system of an off-axis method (method which does not have a point detecting [focal] into the projection visual field of projection lens system PL), and the mark detection system which detects the mark for the alignment on Wafer W by the off-axis method is arranged on the outskirts of the soffit section of the lens-barrel of projection lens system PL as shown in drawing 1 .
[0021] The underside of the optical elements (a lens, a glass plate, prism, etc.) attached at the head of this focal alignment sensor FAD is arranged in Liquid LQ, as shown in drawing 1 , and from that optical element, the lighting beam for alignment and the beam for focal detection are irradiated on the front face of Wafer W (or auxiliary plate section HRS) through Liquid LQ. And a focal leveling detection system outputs the focal signal Sf corresponding to the position error over the best image formation side of the front face of Wafer W, and a mark detection system analyzes the photoelectrical signal corresponding to the optical description of the mark on Wafer W, and outputs the alignment signal Sa showing XY location or the amount of location gaps of a mark.
[0022] And the above focal signal Sf and alignment signal Sa are sent out to a master controller 40, and a master controller 40 sends out the information for driving three each of Z actuator 32A, and B and C the optimal based on the focal signal Sf to the wafer stage controller 35. The wafer stage controller 35 controls Z actuator each 32A, and B and C by this so that the focal adjustment and tilt adjustment to the field which should be projected actually on Wafer W are performed.
[0023] Moreover, a master controller 40 manages the coordinate location of X-Y stage 34 for adjusting the relative physical relationship of Reticle R and Wafer W based on the alignment signal Sa. Furthermore, in case a master controller 40 carries out scan exposure of each shot field on Wafer W, as Reticle R and Wafer W carry out uniform migration with an equal velocity ratio with the projection scale factor of projection lens system PL in the direction of Y, it carries out the synchronousr control of the reticle stage controller 20 and the wafer stage controller 35.
[0024] In addition, the focal alignment sensor FAD in drawing 1 is good to prepare in the direction of Y at two places, and to prepare in the direction of X on both sides of the point of projection lens system PL, at two places [a total of four], although only one place of the point circumference of projection lens system PL is prepared. Moreover, the mark for alignment formed in the periphery of Reticle R and the mark for the alignment on Wafer W (or reference

mark on a reference mark plate) are simultaneously detected above the reticle R in drawing 1 through projection lens system PL, and the alignment sensor 45 of the TTR (SURUZA reticle) method which measures the location gap with Reticle R and Wafer W to high degree of accuracy is formed in it. And the location gap measurement signal from this TTR alignment sensor 45 is sent out to a master controller 40, and is used for positioning of a reticle stage 16 or X-Y stage 34.

[0025] By the way, although the aligner of drawing 1 makes the uniform migration of X-Y stage 34 carry out in the direction of Y and performs scan exposure, it explains the reticle R at the time of the scan exposure, and the schedule of scanning migration of Wafer W and step migration with reference to drawing 2 . In drawing 2 , projection lens system PL in drawing 1 is typically expressed with the pre-group lens system LGa and the rear group lens system LGb, and the exit pupil Ep of projection lens system PL exists between the pre-group lens system LGa and rear group lens system LGb. Moreover, circuit pattern space Pa which has bigger diagonal length than the diameter dimension of the circular image field by the side of the body of projection lens system PL in the reticle R shown in drawing 2 is formed in the inside divided with the protection-from-light band SB.

[0026] And scan exposure of the field Pa on Reticle R is carried out in Reticle R to the shot field SAa to which it corresponded on Wafer W by making the scanning migration of the wafer W carry out in the forward direction in alignment with a Y-axis with constant speed Vw, making scanning migration carry out in the negative direction in alignment with a Y-axis with constant speed Vr. At this time, the field A.I. Artificial Intelligence of the pulse illumination light IL which illuminates Reticle R is set up the shape of the parallel shape of a slit, and a rectangle extended in the direction of X in the field Pa on reticle, as shown in drawing 2 , and the both ends of that direction of X are located on the protection-from-light band SB.

[0027] Now, image formation of the partial pattern contained in the pulse Mitsuteru light region A.I. Artificial Intelligence in the field Pa on Reticle R is carried out to the location where it corresponded in the shot field SAa on Wafer W by projection lens system PL (lens systems LGa and LGb) as an image SI. And completion of a relative scan with pattern space Pa on Reticle R and the shot field SAa on Wafer W carries out step migration only of the constant rate in the direction of Y so that Wafer W may come to the scan starting position to the shot field SAb of the next door of the shot field SAa. The exposure of the pulse illumination light IL is interrupted during this step migration. Next, the pattern image of an electronic circuitry is formed on the shot field SAb by moving Wafer W in the negative direction of a Y-axis with constant speed Vw to a projection image SI, moving Reticle R in the forward direction of a Y-axis with constant speed Vr to the pulse Mitsuteru light region A.I. Artificial Intelligence so that scan exposure of the image of the pattern in the field Pa of Reticle R may be carried out to the shot field SAb on Wafer W. In addition, a technical example which uses the pulsed light from an excimer laser for scan exposure is indicated by for example, the U.S. Pat. No. 4,924,257 number.

[0028] By the way, if drawing 1 and the projection aligner shown in 2 change the configuration and magnitude of opening of a reticle blind within an illumination system 10 and the configuration of the lighting field A.I. Artificial Intelligence is doubled with the circuit pattern space when the diagonal length of the circuit pattern space on Reticle R is smaller than the diameter of the circular image field of projection lens system PL, the equipment of drawing 1 can be used for it as a stepper of a step-and-repeat method. In this case, while exposing the shot field on Wafer W, the reticle stage 16 and X-Y stage 34 are relatively made into the quiescent state. However, what is necessary is just to carry out the fine driving control of the reticle stage

16 so that the jogging may be measured by the laser interferometer system 33 and flattery amendment of the part for the location gap with minute Wafer W to projection lens system PL may be carried out by Reticle R side when Wafer W moves slightly during the exposure. Moreover, when changing the configuration and magnitude of opening of a reticle blind, a zoom lens system which is centralized on the range corresponding to opening after adjusting the pulsed light from the light source which reaches a reticle blind to compensate for modification of an opening configuration or size may be prepared.

[0029] In addition, to the hand of cut of scan exposure of the circumference of a Y-axis, i.e., the direction, since the field of a projection image SI is set up the shape of the shape of a slit, and a rectangle prolonged in the direction of X so that clearly from drawing 2 , tilt adjustment under scan exposure is chiefly performed only in the rolling direction by this example. Of course, the width of face of the scanning direction of the field of a projection image SI is large, and if it is ******, when there is nothing in consideration of the effect of the flatness about the scanning direction on the front face of a wafer, naturally tilt adjustment of the hand of cut of the circumference of the X-axis, i.e., the pitching direction, is also performed during scan exposure.

[0030] Here, the condition of the liquid LQ in the holder table WH which is the description of the aligner by this example is explained with reference to drawing 3 . Drawing 3 expresses the partial cross section from the point of projection lens system PL to the holder table WH. The convex positive lens component LE 1 is being fixed [Underside Pe] at the head in the lens-barrel of projection lens system PL for the top face at the flat surface. The underside Pe of this lens element LE1 is processed so that it may become the end face of the point of lens-barrel hardware, and the same field (flash plate surface processing), and it is suppressing that the flow of Liquid LQ is confused. Beveling processing is carried out with big curvature like drawing 3 , and the periphery corner 114 furthermore soaked in Liquid LQ by the lens-barrel point of projection lens system PL makes resistance to the flow of Liquid LQ small, and suppresses generating and the turbulent flow of an unnecessary eddy. Moreover, the adsorption side 113 where the plurality which carries out vacuum adsorption of the rear face of Wafer W projected is formed in the center of the inner pars basilaris ossis occipitalis of the holder table WH, and it is **. This adsorption side 113 is specifically made from height of about 1mm as two or more zona-orbicularis-like lands formed in the direction of a path of Wafer W in the predetermined pitch concentric circular. And each of the slot engraved in the center of each zona-orbicularis-like land has led to the piping 112 connected to the source of a vacuum for vacuum adsorption inside Table WH.

[0031] Now, in this example, as shown in drawing 3 , the spacing L in the best focus condition of the underside Pe of lens element LE1 at the head of projection lens system PL and the front face of Wafer W (or auxiliary plate section HRS) is set as about 2-1mm. Therefore, the height of the wall LB set up to spacing L around the holder table WH that what is necessary is [therefore] just about 2 to 3 or more times of the depth Hq of the liquid LQ filled in the holder table WH is good at several mm - about 10mm. Thus, the spacing L as working distance of projection lens system PL is written very small, and there are also few total amounts of the liquid LQ filled in the holder table WH, it ends with this example, and temperature control also becomes easy.

[0032] The liquid LQ used by this example here is easy to receive, and handling uses easy pure water. However, at this example, while decreasing the surface tension of Liquid LQ, in order to increase the surface activity force, the additive (liquid) of the aliphatic series system which is not made to dissolve the resist layer of Wafer W, and can disregard the effect to the optical coat of the underside Pe of a lens element is added at few rate. The methyl alcohol which has a

refractive index almost equal to pure water as the additive is desirable. If it does in this way, even if the methyl alcohol component in pure water evaporates and content concentration changes, the advantage that refractive-index change as the whole liquid LQ can be made very small will be acquired.

[0033] Now, although the temperature of Liquid LQ is controlled by fixed precision to a certain target temperature, a current comparison precision which can carry out temperature control easily is about **0.01 degrees C. Then, the realistic immersion projection under such a temperature control precision is considered. general -- the temperature coefficient Na of the refractive index of air -- about -9x10-7/degree C -- it is -- the temperature coefficient Nq of the refractive index of water -- about -- it is -8x10-5/degree C, and the temperature coefficient Nq of the refractive index of water is larger about double figures. On the other hand, when working distance is set to L, amount of wave aberration deltaF of the image formation which originates in amount [of temperature changes (temperature unevenness)] deltaT of the medium which fills working distance L, and is produced is expressed with a degree type in approximation.

deltaF=Land|N|-deltaT [0034] Here, in the usual projection exposure which does not apply immersion projection, amount of wave aberration deltaFair when making 10mm and amount of temperature changes deltaT into 0.01 degrees C is as follows about working distance L.

deltaFair=Land|Na|-delta -- amount of wave aberration deltaFlq obtained under the working distance L with T**0.09nm same again and amount of temperature changes deltaT when immersion projection is applied is as follows.

deltaFlq=L, |Nq|, and deltaT**8nm[0035] The greatest amount of wave aberration deltaFmax by which this amount of wave aberration is generally permitted 1/30 of the operating wavelength lambda or 1 / when ArF excimer laser is used since 50 to about 1/100 is made desirable is set to lambda/30, lambda / about 50 to lambda/100 6.43, or 3.86-1.93nm, and is desirably set to lambda/100 of 1.93nm or less. By the way, each thermal conductivity in 0 degree C of air and water serves as 0.0241 W/mK with air, and it becomes 0.561 W/mK with water, and water of heat conduction is better, it can do smaller than it in air, and the temperature unevenness within the optical path formed underwater can also make small fluctuation of the refractive index generated in a liquid as a result. However, as expressed to the formula (3), when working distance L is about 10mm, even if amount of temperature changes deltaT is 0.01 degrees C, amount of wave aberration deltaFlq to generate will exceed amount of permissible aberration deltaFmax greatly.

[0036] Then, the relation of the amount of temperature changes deltaT and working distance L in consideration of amount of allowance wave aberration deltaFmax is set to deltaFmax=lambda/30>=L-|Nq|-deltaT, or delta Fmax=lambda / 100 >=L, |Nq| and deltaT from the above consideration. Here, if amount of temperature changes deltaT assumed is made into 0.01 degrees C and 193nm and refractive-index variation Nq of Liquid LQ are made into -8x10-5/degree C for wavelength lambda, the working distance (thickness of a liquid layer) L needed will be set to 8mm or 2.4mm or less. It is better to make the working distance L smaller than 2mm desirably within limits to which Liquid LQ flows smoothly. While the temperature control of Liquid LQ becomes easy by constituting like this example as mentioned above, degradation of the projection image produced in the wave aberration change resulting from the temperature change in a liquid layer is suppressed, and it becomes possible to carry out projection exposure of the pattern of Reticle R by very high resolving power.

[0037]

[Explanation of the 2nd example] Next, the 2nd example of this invention is explained with

reference to drawing 4 . This example shows the temperature control method of the applicable liquid LQ, and operating of the liquid LQ at the time of exchange of Wafer W also like the 1st previous example. Therefore, the same sign is attached to previous drawing 1 and the same thing as the member in three in drawing 4 . Now, two or more adsorption sides 113 are formed in the wafer installation section formed in the inner pars basilaris ossis occipitalis of the holder table WH as a circular crevice in drawing 4 . And the slot 51 used for supply and blowdown of Liquid LQ is formed around the circular wafer installation section annularly, and a part of the slot 51 is connected with the external pipe 53 through the path 52 formed in Table WH. Moreover, the heat regulators 50A and 50B, such as a Peltier device, are embedded directly under [of the wafer installation section in the holder table WH], and directly under the auxiliary plate section HRS, a thermo sensor 55 is attached in the suitable location on the holder table WH (desirably two or more places), and the temperature of Liquid LQ is detected by the precision. And heat regulators 50A and 50B are controlled by the controller 60 so that the temperature of the liquid LQ detected by the thermo sensor 55 becomes constant value.

[0038] On the other hand, the pipe 53 is connected to the liquid supply unit 64 and the drainage pump 66 through the change bulb 62. The change bulb 62 answers a command from a controller 60, and it operates so that the passage which supplies the liquid LQ from the liquid supply unit 64 to a pipe 53, and the passage which returns the liquid LQ from a pipe 53 to the supply unit 64 through a drainage pump 66 may be changed. Moreover, in the supply unit 64, thermoregulator 64B which maintains at fixed temperature whole liquid LQ in a tank including pump 64A which supplies Liquid LQ, and its pump 64A from the reserve tank (un-illustrating) which can hold the whole liquid LQ on the holder table WH, and this tank is prepared. Furthermore in the above configuration, each actuation of a bulb 62, pump 64A, thermoregulator 64B, and a drainage pump 66 is controlled by the controller 60 in generalization.

[0039] Now, in such a configuration, if Wafer W is laid on two or more adsorption sides 113 in the condition, PURIARAIMENTO [conveyed and] on the installation section of the holder table WH, reduced pressure immobilization will be carried out through the piping 112 for vacuum adsorption shown in drawing 3 . In the meantime, it is being continued by controlling heat regulators 50A and 50B the temperature used as a target. And if vacuum adsorption of Wafer W is completed, the change bulb 62 will change from a closing location to the supply unit 64 side, the liquid LQ by which the temperature control was carried out will be poured in only for a constant rate inside the wall LB of the holder table WH through a pipe 53, a path 52, and a slot 51 by actuation of pump 64A, and the change bulb 62 will return to a closing location. Then, shortly after the exposure to Wafer W is completed, the change bulb 62 changes from a closing location to a drainage-pump 66 side, and is returned in the reserve tank of the supply unit 64 through the liquid LQ fang furrow 51 on Table WH, and a pipe 53 by actuation of a drainage pump 66. Based on the detecting signal from the thermo sensor in a reserve tank, temperature control of it is carried out to a precision by thermoregulator 64B until the liquid LQ returned in the tank can prepare the following wafer.

[0040] Thus, since according to this example temperature control of the liquid LQ under immersion exposure was carried out, Liquids LQ are collected in the supply unit 64 and it was made to carry out temperature control during wafer exchange actuation with the heat regulators 50A and 50B in the holder table WH, while wafer exchange is attained in atmospheric air, there is an advantage referred to as being able to prevent the big temperature change of Liquid LQ. the liquid LQ which is furthermore poured into the holder table WH after wafer exchange according to this example -- even if -- laying temperature -- receiving -- being small (for example, about

0.5 degrees C) -- though it differs, since the depth Hq (refer to drawing 3) of a liquid layer is shallow generally and laying temperature may be reached comparatively early, the time amount which waits for temperature stability may also be shortened.

[0041]

[Explanation of the 3rd example] Next, the 3rd example is explained with reference to drawing 5 . Drawing 5 expresses the partial cross section of the holder table WH which improved the configuration of previous drawing 3 , the holder table WH of this example has separated on the wafer chuck 90 holding Wafer W, and the ZL stage 82 which performs the Z direction migration and tilt migration for focal leveling, and the wafer chuck 90 is laid on the ZL stage 82. And the ZL stage 82 is formed on X-Y stage 34 through three Z actuators 32A and 32C (32B omits). And the paths 53A and 53B connected to Wall LB, the auxiliary plate section HRS, the piping 112 for vacuum adsorption, supply of Liquid LQ, and the pipe 53 (refer to drawing 4) for blowdown are formed in the chuck 90 like drawing 1 , and 3 and 4, respectively. However, path 53A is connected with the circumference part of the auxiliary plate section HRS of the wafer chuck 90 interior, and path 53B is connected with the lowest part of the wafer installation section of the pars basilaris ossis occipitalis in the wafer chuck 90. Thus, formation of the path for liquid blowdown and the impregnation in the wafer chuck 90 to two or more places performs receipts and payments of a liquid promptly.

[0042] Furthermore, by this example, three breakthroughs (two are illustrated) 91 are formed in the center section of a chuck 90, and three pin center,large rise pins (two are illustrated) 83 which move up and down through this breakthrough 91 are formed on the vertical-movement drive 85. Besides, the downward moving drive 85 is fixed to an X-Y stage 34 side. The three pin center,large rise pins 83 are for only a constant rate lifting the wafer W on a chuck 90 from an installation side at the time of wafer exchange, or taking down Wafer W on an installation side, and where vacuum adsorption of the wafer W is carried out in the installation side of a chuck 90, as shown in drawing 5 , the apical surface of the pin center,large rise pin 83 is set as the location which fell rather than the installation side of a chuck 90.

[0043] On the other hand, it is constituted by the point of projection lens system PL used by this example so that the parallel plate CG of the quartz fixed at right angles to an optical axis AX may be attached at the head of the sub lens-barrel 80, therefore lens element LE1 (plano-convex lens) at a head may not be soaked in Liquid LQ. In this example, spacing of the underside of this parallel plate CG and the front face of Wafer W serves as working distance on appearance, and is set as 2mm or less like a previous example. Moreover, the anchoring side with the parallel plate CG of the sub lens-barrel 80 is waterproofed, and the interior of the sub lens-barrel 80 is filled up with nitrogen gas.

[0044] Thus, if the parallel plate CG is formed at the head of projection lens system PL, even if a substantial back focus distance (distance from the optical element at a head with refractive power to the image surface) of projection lens system PL is about 10-15mm, the immersion projection which working distance L was easily set [projection] to about 1-2mm, and reduced the effect of the temperature change of a liquid is realizable. Moreover, since the parallel plate CG can be formed by post-installation, it becomes possible [correcting easily the local very small distortion aberration (or random distortion) produced within the projection image] by grinding a part of front face of the parallel plate CG to the 1/several about order of wavelength. That is, the parallel plate CG will combine the function as an aperture which protects the latest lens element of projection lens system PL from a liquid, and the function as a distortion compensation plate. In addition, since the image formation engine performance of projection lens system PL including

the parallel plate CG is guaranteed if another view is carried out, a change does not have the parallel plate CG in it being the latest optical element of projection lens system PL.
[0045]
[Explanation of the 4th example] Next, the 4th example of this invention is explained with reference to drawing 6 . This example is connected also with the example shown in previous drawing 5 , and is related with the wafer exchange at the time of using the projection optical system which made working distance very small for the immersion projection exposing method. In drawing 6 , the reference mirror ML (the object for the directions of X and for the directions of Y) reflected in response to the beam BSr for reference from the laser interferometer 33 shown in drawing 1 is being fixed to the soffit section of the lens-barrel of projection lens system PL. And the beam BSm for length measurement from a laser interferometer 33 is projected by the migration mirror MRw fixed to the edge of the ZL stage 82 as shown in previous drawing 5 , the reflective beam interferes in a laser interferometer 33 with the reflective beam of return and the beam BSr for reference, and the coordinate location of the reflector of the migration mirror MRw, i.e., X of Wafer W, and the coordinate location of the direction of Y are measured on the basis of the reference mirror ML. Now, also in this example, the ZL stage 82 is attached on X-Y stage 34 through three Z actuators 32A and 32B (32C omits), and is movable in a Z direction and the direction of a tilt. However, it is combined with X-Y stage 34 through flat springs 84A and 84B (84C omits) by three places of the circumference of it, and the ZL stage 82 is supported so that the rigidity of the horizontal direction (inside of XY side) to X-Y stage 34 may become very large.
[0046] And although the wafer chuck 90 as previous drawing 5 also with the same this example is formed on the ZL stage 82, a different point from drawing 5 is having made it the configuration which boils the wafer chuck 90 comparatively with the drives 88A and 88B of two or more Z directions, and moves to a Z direction to the ZL stage 82 by big stroke (about 10-15mm). unlike Z actuator 32A for focal leveling, and B and C, these drives 88A and 88B move the wafer chuck 90 among the ends of that stroke -- sufficient -- it is good at the easy elevation function using an air cylinder, a link mechanism, etc. Furthermore in the example of drawing 6 , it is fixed, without the pin center,large rise pin 83 shown in previous drawing 5 moving up and down on X-Y stage 34. And after the wafer chuck 90 has gone up most like drawing 6 , the front face of Wafer W was set as about 1-2mm from the field of the optical element at the head of projection lens system PL, and the apical surface of the pin center,large rise pin 83 has fallen to the down side (about 2-3mm) more slightly than the wafer installation side of the wafer chuck 90.
[0047] With the above configurations, drawing 6 will discharge the liquid LQ on the wafer chuck 90 temporarily by blowdown actuation of the liquid LQ shown in previous drawing 4 , if the condition at the time of the exposure actuation to Wafer W is expressed and the exposure actuation is completed. Then, if vacuum adsorption of the wafer chuck 90 is canceled, Drives 88A and 88B will be operated and the wafer chuck 90 will be brought down at the bottom from the location of drawing 6 . While Wafer W is again carried by this on three apical surfaces of the pin center,large rise pin 83, it is positioned so that the upper bed side of the wall LB of the wafer chuck 90 circumference may become lower than the apical surface (the inside of drawing 3 the inside of the underside Pe of lens element LE1, and drawing 5 underside of the parallel plate CG) of projection lens system PL. If X-Y stage 34 is moved to a wafer exchange location in the condition, Wafer W will be pulled out from directly under [of projection lens system PL], and will move to the direction of the arm 95 for conveyance. It is in the condition set as height which

becomes lower than the wafer W on the pin center,large rise pin 83 more highly than the upper bed side of the wall LB of the wafer chuck 90 at this time as for an arm 95, and enters into Wafer W bottom. And an arm 90 performs vacuum adsorption, lifting Wafer W slightly upward, and conveys Wafer W towards a predetermined unload location. Carrying in of Wafer W is completely carried out to reverse with the above sequence.
[0048] By the way, since the pool of Liquid LQ spreads out directly under the optical path of a reference beam BSr in the case of a method with which a laser interferometer 33 projects a reference beam BSr on the reference mirror ML of projection lens system PL as shown in drawing 6 , it is possible to give fluctuation to the optical path of a reference beam BSr by lifting of the saturated steam of the liquid LQ. So, in this example, the covering plate 87 is arranged between the optical path of a reference beam BSr, and Liquid LQ, and the fluctuation which intercepts the steamy style which goes up from Liquid LQ, and is generated in the optical path of a reference beam BSr is prevented.
[0049] In addition, the up space of the covering plate 87 may be ventilated in the pure air by which temperature control was carried out in the direction which intersects an optical path, in order to make the optical path of a reference beam BSr stability more. In this case, the covering plate 87 will be equipped also with the function to prevent that the air for optical-path air conditioning is sprayed on the direct liquid LQ, and can reduce unnecessary evaporation of Liquid LQ. Moreover, it may replace with the mere covering plate 87, and the whole optical path of a reference beam BSr may be made a wrap configuration with a windshield tube.
[0050]
[Explanation of the 5th example] Next, the 5th example of this invention is explained with reference to drawing 7 (A) and (B). This example combines the pin center,large rise device (a pin 83, Z actuator 85) shown in drawing 5 with the structure of the holder table WH shown in previous drawing 1 , and it improves the holder table WH so that wafer exchange may be simplified. And drawing 7 (B) expresses the flat surface of the improved holder table WH, and drawing 7 (A) expresses the cross section of 7A view in drawing 7 (B). The holder table WH is held through three Z actuators 32A and 32C (32B omits) on X-Y stage 34, and three breakthroughs 91 are formed near the center of the holder table WH so that the drawing 7 (A) and (B) may show. In this breakthrough 91, the pin center,large rise pin 83 which moves up and down by the actuator 85 passes.
[0051] As explained also in advance, if the height of the lowest end face of projection lens system PL remains as it is, it is separated from the front face of the auxiliary plate section HRS (wafer W) only about 2mm. The upper bed of the wall LB furthermore prepared around the holder table WH is higher than the lowest end face of projection lens system PL. Therefore, when it constitutes so that X-Y stage 34 may be moved as it is for wafer exchange and a wafer may be pulled out from directly under [of projection lens system PL], a part of width of face of the auxiliary plate section HRS will enlarge content volume of the holder table WH on which the diameter dimension extent required next door of the lens-barrel of projection lens system PL and Liquid LQ are poured in.
[0052] So, in this example, as shown in drawing 7 , a part of wall LB of the holder table WH was cut and lacked, and the fluid-tight door section DB which can be opened and closed freely there was formed. While Liquid LQ is poured in, this fluid-tight door section DB has always closed the notching section of Wall LB in the state of fluid-tight, as shown in drawing 7 (A) and (B), and if Liquid LQ is discharged from the holder table WH, it will open it like the broken line in drawing 7 (A). In the condition of having opened, the fluid-tight door section DB is set up so that

it may become low a little rather than the height of the front face of the auxiliary plate section HRS. Moreover, O ring OLs (notching section of Wall LB etc.) who ensure fluid-tight nature like drawing 7 (B) are prepared in the proper location at a part for the wall by the side of the holder table WH body which touches the wall of the fluid-tight door section DB.

[0053] In the above configurations, when exchanging the wafer on the holder table WH, after discharging the liquid LQ in the holder table WH first, the fluid-tight door section DB is opened. Then, when X-Y stage 34 is moved to right-hand side in drawing 7 , a wafer will be pulled out from directly under [of projection lens system PL]. Projection lens system PL is located in the headroom of the fluid-tight door section DB opened exactly at this time. And a wafer is easily exchangeable, if the pin center,large rise pin 83 is raised and a wafer is lifted more highly than Wall LB.

[0054] There is an advantage temperature management of Liquid LQ not only becomes easy, but that become possible to make into min the diameter of the wall LB which encloses the perimeter of the holder table WH according to this example, become possible to stop the total amount of the liquid LQ filled in the holder table WH to the minimum, and the impregnation blowdown time amount of Liquid LQ becomes min. In addition, although it is not necessary at the time of the configuration of said 4th example to prepare the fluid-tight door section especially since a wafer chuck descends, in the configuration of the 4th example, the fluid-tight door section may be prepared still more.

[0055]

[Explanation of the 6th example] Next, drawing 8 shows the 6th example of this invention, and uses the lower container 7 and the up container 8 in this example. Wafer electrode-holder 3a which lays a wafer 3 is formed in the inner surface pars basilaris ossis occipitalis of the lower container 7, the top face of the lower container 7 is sealed by the base of the up container 8, and the complete product of the lower container 7 is thoroughly filled by immersion liquid 7a. Immersion liquid 8a is filled by the another side up container 8, and last lens side 1a of a projection optical system 1 is dipped in the immersion liquid 8a.

[0056] A part of immersion liquid 7a in the lower container 7 is led to a thermoregulator 6 from the exhaust port 5 prepared in one side face of the lower container 7, and in a thermoregulator 6, it circulates through temperature control so that it may return to the lower part [inlet / 4 / which was established in the other side faces of the lower container 7 after the carrier beam] container 7. The thermo sensor (not shown) is attached in two or more [in the lower container 7], and based on the output from a thermo sensor, the thermoregulator 6 is controlled so that the temperature of immersion liquid 7a in the lower container 7 becomes fixed. Moreover, the same temperature regulatory mechanism is prepared also about immersion liquid 8a in the up container 8.

[0057] In this example, the wafer 3 is moved by moving the lower container 7 and the up container 8 as one. On the other hand, since the immersion liquid in the lower container which held the wafer 3 is sealed substantially, it is not only advantageous in respect of temperature stability, but it does not generate the pressure distribution by flow, such as an eddy in an immersion liquid. that is , although the pressure distribution in an immersion liquid serve as fluctuation of a refractive index and it become the factor of image formation wave aberration aggravation , that pressure distribution become a problem in this 6th example be only immersion liquid 8a filled by the up container 8 , and it can ease the effect of the immersion liquid flow of the time of wafer migration by forming the optical path L8 of this part short enough to the level which do not become a problem practically .

[0058] In addition, although the lower container 7 and the up container 8 were moved as one in this example, only the lower container 7 can be moved and the up container 8 can also be fixed. Immersion liquid 8a in the up container 8 will stop thoroughly at the time of this configuration. Therefore, among working distances L, it is desirable to form thinly enough the thickness L7 of immersion liquid 7a in the lower part [thickness / L8 / of immersion liquid 8a in the up container 8] container 7.

[0059]

[Explanation of other modifications] As mentioned above, although each example of this invention was explained, as shown in previous drawing 1 , since the working distance at the time of immersion projection exposure is very as small as about 1-2mm, focusing to Wafer W shall use the focal alignment sensor FAD of an off-axis method. However, the focal detection device of the TTL (SURUZA lens) method which projects the beam for focal detection on a wafer through the periphery within the projection visual field of projection lens system PL, and measures the height location or inclination on the front face of a wafer may be established as indicated by the U.S. Pat. No. 4,801,977 number, the U.S. Pat. No. 4,383,757 number, etc., for example.

[0060] Moreover, although the focal alignment sensor FAD shown in drawing 1 shall detect the alignment mark on Wafer W optically by the off-axis method, it is good also as an alignment sensor of the TTL method which detects the mark on Wafer W other than the TTR alignment sensor 45 in drawing 1 to which this alignment sensor also detects the mark on Wafer W through Reticle R and projection lens system PL only through projection lens system PL. Furthermore, if it has the projection optical system which carries out projection exposure under an ultraviolet-rays region (wavelength of 400nm or less), this invention can completely be similarly applied, even if it is the aligner of what kind of configuration.

[0061]

[Effect of the Invention] By this invention, the aligner of an immersion type with which image formation engine performance sufficient within the limits of a realizable temperature control was guaranteed was offered as mentioned above. Moreover, the structure of a wafer stage of having been suitable for loading and unloading of a wafer in an immersion photolithography system was also offered.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates especially to the aligner of an immersion type about the aligner which bakes the pattern drawn on reticle on a wafer according to a projection optical system.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Although spacing between the last lens side of optical system and the image surface was called working distance, the working distance of the projection optical system of the conventional aligner was filled with air. As for this working distance, it was common to have taken 10mm or more on account of making autofocus optical system intervene etc. On the other hand, the detailed-ization is desired increasingly and it is necessary to attain short wavelength-ization of exposure wavelength for that purpose, or to aim at buildup of numerical aperture about the pattern imprinted to a wafer. However, since there is a limit in the class of glass ingredient which penetrates the light of short wavelength, the aligner of the immersion type which attains detailed-ization of an exposure pattern is proposed by filling working distance with a liquid and aiming at buildup of numerical aperture.
[0003] In the aligner of an immersion type, there is a possibility that distribution may arise in a refractive index according to the temperature distribution of the liquid made to be placed between working distances. Then, the following techniques are proposed as a cure to degradation of the image formation engine performance resulting from the temperature change of a liquid. That is, the technique indicated by <u>drawing 3</u> of a U.S. Pat. No. 4,346,164 number is proposed according to the temperature stability device of a liquid (**) as what attains stabilization of temperature, and the technique indicated by JP,6-124873,A is proposed as what attains equalization of temperature by the excitation agitator style. Moreover, measuring temperature or a refractive index to JP,6-124873,A similarly as what is fed back to temperature control according to the temperature monitor device of a liquid (being) is proposed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] By this invention, the aligner of an immersion type with which image formation engine performance sufficient within the limits of a realizable temperature control was guaranteed was offered as mentioned above. Moreover, the structure of a wafer stage of having been suitable for loading and unloading of a wafer in an immersion photolithography system was also offered.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However (**), if it sets and how many temperature is stabilized, as shown below actually, the temperature control in the precision which is hard to be

referred to as realistic is needed [the argument referred to as whether it is satisfactory practically is not accomplished, but]. moreover -- (-- it is --) -- ******** -- if it takes into consideration that the temperature ununiformity of a liquid influences the image formation engine performance most, it will be hard to call it an effective cure. Thus, it was in the situation which cannot be conventionally referred to as that there is no example which mentioned the constraint about the optical parameter of a projection optical system like working distance itself in the well-known technique about an immersion photolithography system, and the special conditions of an immersion type are taken into consideration. Therefore, this invention makes easy temperature control of the liquid which fills working distance, and makes it a technical problem to offer the immersion photolithography system which does not cause degradation of the image formation engine performance.

[Translation done.]

MEANS

[Means for Solving the Problem] It is made in order that this invention may solve the above-mentioned technical problem. It has the projection optical system which carries out the printing imprint of the pattern drawn on reticle on a wafer. In the immersion photolithography system which filled at least the part of the working distances between the lens sides and wafers which approached the wafer of this projection optical system most with the liquid which penetrates exposure light When the die length of working distance is set to L, wavelength of exposure light is set to lambda and the temperature coefficient of the refractive index of a liquid is set to N (1-/degree C), it is L<=lambda/(0.3x|N|).
It is the immersion photolithography system characterized by forming so that it may become, and it is the immersion photolithography system characterized by using what added the additive which decreases the surface tension of pure water or increases whenever [surface activity / of pure water] as said liquid to pure water.
[0006] An operation of this invention is explained below. If set the distance from the glass side at the head of a projection optical system to an image formation side, i.e., working distance, to L, width of face of the temperature distribution of the medium which fills working distance L is set to deltaT, aberration of the image formation wave front resulting from this temperature-distribution deltaT is set to deltaF and the temperature coefficient of the refractive index of a liquid is set to N, the following formulas (1) will be materialized in approximation.
deltaF=Lx|N|xdeltaT .... (1)
[0007] About temperature-distribution deltaT of a medium, in order to attain the equalization, it controls how and a way is assumed that about [deltaT=0.01 degree C] temperature distribution exist. Therefore, image formation wave aberration deltaF is deltaF=Lx|N|x0.01 at least. .... (1a)
**** exists. N is the value which expressed the temperature coefficient of a refractive index with the 1/degree-C unit here.
[0008] The values of the temperature coefficient N of a refractive index differ greatly with a liquid and a gas, for example, with air, to being N=-9x10-7/degree C, in the case of water, it is N=-8x10-5/degree C, and it has an about 100 times as many difference as this. On the other

hand, although the working distance L of the projection optical system of a cutback projection aligner is usually L> 10mm, though it is L= 10mm, image formation wave aberration deltaF of the working distance is as follows.
Air: deltaF=10mmx|-9x10-7/degree-C|x0.01 degree C = 0.09nm Water : deltaF=10mmx|-8x10-5/degree-C|x0.01 degree C = 8.0nm [0009] However, generally, 1/30 or less [of the exposure wavelength lambda] is desirable, namely, image formation wave aberration deltaF is delta F<=lambda / 30. .... (2)
******(ing) is desirable. For example, deltaF<6.4nm is desirable when using an ArF excimer laser with a wavelength of 193nm as an exposure light. When the medium which fills working distance is water, by L> 10mm, it turns out like the conventional technique that the yield of the image formation wave aberration according [working distance L] to the temperature distribution of a medium is too large, and a problem is produced practically.
[0010] (1a) From a formula and (2) types to L<=lambda/(0.3x|N|) .... (3)
******. Therefore, by filling (3) types, the immersion photolithography system which carried the projection optical system by which the wave aberration yield produced according to the temperature distribution in an immersion liquid on the basis of realizable temperature stability (temperature distribution) was stopped by 1/30 or less [of exposure wavelength] is obtained. The amount of wave aberration generated because exposure light passes through the inside of the medium which had temperature distribution in this invention is easing the demand to temperature distribution by preparing the optical path length an upper limit as mentioned above paying attention to being dependent on the product of the optical path length in the amount of temperature distributions, and a medium. Practical use can be presented with an immersion photolithography system under the temperature control of the immersion liquid in level realizable by this.
[0011]
[Embodiment of the Invention] Some suitable examples for this invention are explained below.
[0012]
[Explanation of the 1st example] Drawing 1 shows the whole projection aligner configuration by the 1st example of this invention, and it shows the projection aligner of the lens scanning method which carries out the relative scan of Reticle R and the wafer W to projection lens system PL here, projecting the circuit pattern on Reticle R on the semi-conductor wafer W through cutback projection lens-system PL which has the circular image field constituted by the tele cent rucksack in the both sides by the side of a body and an image. The ArF excimer laser to which an illumination system 10 emits pulsed light with a wavelength of 193nm in drawing 1 (un-illustrating), The beam expander which operates the cross-section configuration of the pulsed light from the light source orthopedically (un-illustrating), Optical integrators, such as a fly eye lens which carries out incidence of the pulsed light operated orthopedically, and generates secondary light source images (meeting of two or more point light sources) (un-illustrating), The condenser lens system which makes pulsed light from the secondary light source image the pulse illumination light of uniform illuminance distribution (un-illustrating), The reticle blind which operates the configuration of the pulse illumination light orthopedically in the shape of [long] a rectangle in the direction (the direction of X) which intersected perpendicularly with the scanning direction at the time of scan exposure (the direction of Y) (an illuminated viewing field diaphragm) The relay optical system (un-illustrating) for collaborating with the condenser-lens system 12 in drawing 1 and a mirror 14, and carrying out image formation of the pulsed light IL from opening of the shape of un-illustrating and a rectangle of the reticle blind on Reticle R as a

lighting field A.I. Artificial Intelligence of the shape of the shape of a slit and a rectangle is included.

[0013] At the time of scan exposure, vacuum adsorption (depending on the case, they are electrostatic adsorption and machine conclusion) of the reticle R is carried out in the direction of one dimension on the movable uniform reticle stage 16 by big stroke. In drawing 1 , a reticle stage 16 is guided so that scanning migration of the column structure 19 top of the body of equipment may be carried out at the right and left in drawing (the direction of Y), and it is guided so that it may move also in the direction (the direction of X) vertical to the space of drawing. The coordinate location and minute rotation in XY flat surface of the reticle stage 16 project a laser beam on the migration mirror (a plane mirror and corner mirror) MRr attached in a part of reticle stage 16, and are serially measured by the laser interferometer system 17 which receives the reflective beam. And the reticle stage controller 20 controls the motors 18, such as a linear motor for driving a reticle stage 16 based on XY coordinate location measured by interferometer systems 17, and a voice coil, and controls migration of the scanning direction of a reticle stage 16, and migration of the non-scanning direction.

[0014] Now, if the rectangle-like pulse illumination light IL injected from the condenser-lens system 12 and the mirror 14 irradiates a part of circuit pattern space on Reticle R, the image formation flux of light from the pattern which exists in the lighting field A.I. Artificial Intelligence will let 1/4 time as many cutback projection lens system PL as this pass, and image formation projection will be carried out at the sensitive resist layer applied to the front face of Wafer W. The optical axis AX of the projection lens system PL passes along the central point of the circular image field, and it is arranged so that it may become the same axle also to each optical axis of an illumination system 10 and the condenser-lens system 12. Moreover, projection lens system PL consists of lens elements of two or more sheets made from two kinds of ** material, a quartz and a fluorite, which has high permeability to ultraviolet rays with a wavelength of 193nm, and a fluorite is used for the lens element which mainly has forward power. The interior of the lens-barrel which furthermore fixes the lens element of two or more sheets of projection lens system PL is permuted by nitrogen gas, in order to avoid absorption by the oxygen of the pulse illumination light with a wavelength of 193nm. The permutation by such nitrogen gas is similarly performed to the optical path from the interior of an illumination system 10 to the condenser-lens system 12 (or mirror 14).

[0015] By the way, Wafer W is held on the holder table WH which adsorbs the rear face. Wall LB is formed in the whole periphery section of this holder table WH in fixed height, and Liquid LQ is filled with the predetermined depth inside this wall LB. And vacuum adsorption of the wafer W is carried out at the hollow part of the inner pars basilaris ossis occipitalis of the holder table WH. Moreover, the annular auxiliary plate section HRS which encloses the periphery of Wafer W by predetermined width of face is formed around the inner pars basilaris ossis occipitalis of the holder table WH. It is determined that the height of the front face of this auxiliary plate section HRS is mostly in agreement with the height of the front face of the standard wafer W which adsorbed on the holder table WH.

[0016] The main functions of this auxiliary plate section HRS are used as a focal detection side of an alternative of a case so that the detecting point of a focal leveling sensor may be located in the outside of the appearance edge of Wafer W. Moreover, the auxiliary plate section HRS can be used also [calibration / the calibration of the alignment sensor used when carrying out alignment of the shot field on Wafer W, and the circuit pattern on Reticle R relatively, and / of the focal leveling sensor used when carrying out scan exposure of the shot field]. However, it is

more desirable to use for the calibration of an alignment sensor or a focal leveling sensor the reference mark plate of the dedication established according to the auxiliary plate section HRS and an individual. In this case, it will be attached on the holder table WH so that a reference mark plate may also become the almost same height as the projection image side of projection lens system PL in the state of immersion, and an alignment sensor will detect various kinds of reference marks formed on the reference mark plate in the state of immersion. In addition, an example of the approach of carrying out the calibration of the system offset of a focal sensor using the reference mark plate on a table is indicated by for example, the U.S. Pat. No. 4,650,983 number, and an example of the calibration approach of various alignment sensors is indicated by for example, the U.S. Pat. No. 5,243,195 number.

[0017] By the way, since the point of projection lens system PL is soaked in Liquid LQ in this example as shown in drawing 1 , the point at least has the structure where it is waterproofed and a liquid does not sink in in a lens-barrel. Furthermore, the underside (opposed face with Wafer W) of the lens element at the head of projection lens system PL is processed into a flat surface or a convex with very large radius of curvature, and, thereby, can make smooth flow of the liquid LQ produced between the underside of a lens element, and the front face of Wafer W at the time of scan exposure. Furthermore, by this example, although explained to a detail later, the best image formation side (reticle conjugation side) of projection lens system PL in an immersion condition is designed so that it may be formed in the location of about 2-1mm from the underside of the lens element at a head. Therefore, while the thickness of the liquid layer formed between the underside of the lens element at a head and the front face of Wafer W is also set to about 2-1mm and the control precision of the temperature control of Liquid LQ is eased by this, it becomes possible to also suppress generating of the temperature-distribution nonuniformity in the liquid layer.

[0018] Now, the holder table WH is attached on X-Y stage 34 so that the advancing-side-by-side migration (it moves slightly with rough migration in this example) to the Z direction in alignment with the optical axis AX of projection lens system PL and dip jogging to XY flat surface vertical to an optical axis AX may be possible. This X-Y stage 34 carries out two-dimensional migration of the base surface plate 30 top in the XY direction, and the holder table WH is attached through three actuators 32A, 32B, and 32C for Z directions on X-Y stage 34. Each actuator 32A, and B and C consist of combination devices of a piezo flexible component, a voice coil motor, a DC motor, and a lift cam etc. And if only the same amount makes a Z direction drive three Z actuators, parallel translation of the holder table WH can be carried out to a Z direction (the direction of a focus), and if only a mutually different amount makes a Z direction drive three Z actuators, the dip (tilt) direction and amount of the holder table WH can be adjusted.

[0019] Moreover, two-dimensional migration of X-Y stage 34 is performed by the drive motor 36 which consists of linear motors which make the DC motor made to rotate a delivery screw and non-contact generate a thrust. Control of this drive motor 36 is performed by the wafer stage controller 35 which inputs the measurement coordinate location from the laser interferometer 33 which measures each location change of the direction of X of the reflector of the migration mirror MRw fixed to the edge of the holder table WH, and the direction of Y. In addition, as a whole X-Y stage 34 configuration which used the drive motor 36 as the linear motor, the configuration indicated by JP,8-233964,A, for example may be used.

[0020] Now, in this example, since the working distance of projection lens system PL is small and Liquid LQ is filled in narrow spacing of about 2-1mm between the lens element at the head

of the projection lens PL, and Wafer W, it is difficult to project aslant on the wafer side corresponding to the projection visual field of projection lens system PL the floodlighting beam of the focal sensor of an oblique incidence light method. For this reason, in this example, the focal alignment sensor FAD containing the focal leveling detection system of an off-axis method (method which does not have a point detecting [focal] into the projection visual field of projection lens system PL), and the mark detection system which detects the mark for the alignment on Wafer W by the off-axis method is arranged on the outskirts of the soffit section of the lens-barrel of projection lens system PL as shown in drawing 1 .

[0021] The underside of the optical elements (a lens, a glass plate, prism, etc.) attached at the head of this focal alignment sensor FAD is arranged in Liquid LQ, as shown in drawing 1 , and from that optical element, the lighting beam for alignment and the beam for focal detection are irradiated on the front face of Wafer W (or auxiliary plate section HRS) through Liquid LQ. And a focal leveling detection system outputs the focal signal Sf corresponding to the position error over the best image formation side of the front face of Wafer W, and a mark detection system analyzes the photoelectrical signal corresponding to the optical description of the mark on Wafer W, and outputs the alignment signal Sa showing XY location or the amount of location gaps of a mark.

[0022] And the above focal signal Sf and alignment signal Sa are sent out to a master controller 40, and a master controller 40 sends out the information for driving three each of Z actuator 32A, and B and C the optimal based on the focal signal Sf to the wafer stage controller 35. The wafer stage controller 35 controls Z actuator each 32A, and B and C by this so that the focal adjustment and tilt adjustment to the field which should be projected actually on Wafer W are performed.

[0023] Moreover, a master controller 40 manages the coordinate location of X-Y stage 34 for adjusting the relative physical relationship of Reticle R and Wafer W based on the alignment signal Sa. Furthermore, in case a master controller 40 carries out scan exposure of each shot field on Wafer W, as Reticle R and Wafer W carry out uniform migration with an equal velocity ratio with the projection scale factor of projection lens system PL in the direction of Y, it carries out the synchronousr control of the reticle stage controller 20 and the wafer stage controller 35.

[0024] In addition, the focal alignment sensor FAD in drawing 1 is good to prepare in the direction of Y at two places, and to prepare in the direction of X on both sides of the point of projection lens system PL, at two places [a total of four], although only one place of the point circumference of projection lens system PL is prepared. Moreover, the mark for alignment formed in the periphery of Reticle R and the mark for the alignment on Wafer W (or reference mark on a reference mark plate) are simultaneously detected above the reticle R in drawing 1 through projection lens system PL, and the alignment sensor 45 of the TTR (SURUZA reticle) method which measures the location gap with Reticle R and Wafer W to high degree of accuracy is formed in it. And the location gap measurement signal from this TTR alignment sensor 45 is sent out to a master controller 40, and is used for positioning of a reticle stage 16 or X-Y stage 34.

[0025] By the way, although the aligner of drawing 1 makes the uniform migration of X-Y stage 34 carry out in the direction of Y and performs scan exposure, it explains the reticle R at the time of the scan exposure, and the schedule of scanning migration of Wafer W and step migration with reference to drawing 2 . In drawing 2 , projection lens system PL in drawing 1 is typically expressed with the pre-group lens system LGa and the rear group lens system LGb, and the exit pupil Ep of projection lens system PL exists between the pre-group lens system LGa and rear group lens system LGb. Moreover, circuit pattern space Pa which has bigger diagonal length

than the diameter dimension of the circular image field by the side of the body of projection lens system PL in the reticle R shown in drawing 2 is formed in the inside divided with the protection-from-light band SB.
[0026] And scan exposure of the field Pa on Reticle R is carried out in Reticle R to the shot field SAa to which it corresponded on Wafer W by making the scanning migration of the wafer W carry out in the forward direction in alignment with a Y-axis with constant speed Vw, making scanning migration carry out in the negative direction in alignment with a Y-axis with constant speed Vr. At this time, the field A.I. Artificial Intelligence of the pulse illumination light IL which illuminates Reticle R is set up the shape of the parallel shape of a slit, and a rectangle extended in the direction of X in the field Pa on reticle, as shown in drawing 2 , and the both ends of that direction of X are located on the protection-from-light band SB.
[0027] Now, image formation of the partial pattern contained in the pulse Mitsuteru light region A.I. Artificial Intelligence in the field Pa on Reticle R is carried out to the location where it corresponded in the shot field SAa on Wafer W by projection lens system PL (lens systems LGa and LGb) as an image SI. And completion of a relative scan with pattern space Pa on Reticle R and the shot field SAa on Wafer W carries out step migration only of the constant rate in the direction of Y so that Wafer W may come to the scan starting position to the shot field SAb of the next door of the shot field SAa. The exposure of the pulse illumination light IL is interrupted during this step migration. Next, the pattern image of an electronic circuitry is formed on the shot field SAb by moving Wafer W in the negative direction of a Y-axis with constant speed Vw to a projection image SI, moving Reticle R in the forward direction of a Y-axis with constant speed Vr to the pulse Mitsuteru light region A.I. Artificial Intelligence so that scan exposure of the image of the pattern in the field Pa of Reticle R may be carried out to the shot field SAb on Wafer W. In addition, a technical example which uses the pulsed light from an excimer laser for scan exposure is indicated by for example, the U.S. Pat. No. 4,924,257 number.
[0028] By the way, if drawing 1 and the projection aligner shown in 2 change the configuration and magnitude of opening of a reticle blind within an illumination system 10 and the configuration of the lighting field A.I. Artificial Intelligence is doubled with the circuit pattern space when the diagonal length of the circuit pattern space on Reticle R is smaller than the diameter of the circular image field of projection lens system PL, the equipment of drawing 1 can be used for it as a stepper of a step-and-repeat method. In this case, while exposing the shot field on Wafer W, the reticle stage 16 and X-Y stage 34 are relatively made into the quiescent state. However, what is necessary is just to carry out the fine driving control of the reticle stage 16 so that the jogging may be measured by the laser interferometer system 33 and flattery amendment of the part for the location gap with minute Wafer W to projection lens system PL may be carried out by Reticle R side when Wafer W moves slightly during the exposure. Moreover, when changing the configuration and magnitude of opening of a reticle blind, a zoom lens system which is centralized on the range corresponding to opening after adjusting the pulsed light from the light source which reaches a reticle blind to compensate for modification of an opening configuration or size may be prepared.
[0029] In addition, to the hand of cut of scan exposure of the circumference of a Y-axis, i.e., the direction, since the field of a projection image SI is set up the shape of the shape of a slit, and a rectangle prolonged in the direction of X so that clearly from drawing 2 , tilt adjustment under scan exposure is chiefly performed only in the rolling direction by this example. Of course, the width of face of the scanning direction of the field of a projection image SI is large, and if it is ******, when there is nothing in consideration of the effect of the flatness about the scanning

direction on the front face of a wafer, naturally tilt adjustment of the hand of cut of the circumference of the X-axis, i.e., the pitching direction, is also performed during scan exposure.
[0030] Here, the condition of the liquid LQ in the holder table WH which is the description of the aligner by this example is explained with reference to drawing 3 . Drawing 3 expresses the partial cross section from the point of projection lens system PL to the holder table WH. The convex positive lens component LE 1 is being fixed [Underside Pe] at the head in the lens-barrel of projection lens system PL for the top face at the flat surface. The underside Pe of this lens element LE1 is processed so that it may become the end face of the point of lens-barrel hardware, and the same field (flash plate surface processing), and it is suppressing that the flow of Liquid LQ is confused. Beveling processing is carried out with big curvature like drawing 3 , and the periphery corner 114 furthermore soaked in Liquid LQ by the lens-barrel point of projection lens system PL makes resistance to the flow of Liquid LQ small, and suppresses generating and the turbulent flow of an unnecessary eddy. Moreover, the adsorption side 113 where the plurality which carries out vacuum adsorption of the rear face of Wafer W projected is formed in the center of the inner pars basilaris ossis occipitalis of the holder table WH, and it is **. This adsorption side 113 is specifically made from height of about 1mm as two or more zona-orbicularis-like lands formed in the direction of a path of Wafer W in the predetermined pitch concentric circular. And each of the slot engraved in the center of each zona-orbicularis-like land has led to the piping 112 connected to the source of a vacuum for vacuum adsorption inside Table WH.
[0031] Now, in this example, as shown in drawing 3 , the spacing L in the best focus condition of the underside Pe of lens element LE1 at the head of projection lens system PL and the front face of Wafer W (or auxiliary plate section HRS) is set as about 2-1mm. Therefore, the height of the wall LB set up to spacing L around the holder table WH that what is necessary is [therefore] just about 2 to 3 or more times of the depth Hq of the liquid LQ filled in the holder table WH is good at several mm - about 10mm. Thus, the spacing L as working distance of projection lens system PL is written very small, and there are also few total amounts of the liquid LQ filled in the holder table WH, it ends with this example, and temperature control also becomes easy.
[0032] The liquid LQ used by this example here is easy to receive, and handling uses easy pure water. However, at this example, while decreasing the surface tension of Liquid LQ, in order to increase the surface activity force, the additive (liquid) of the aliphatic series system which is not made to dissolve the resist layer of Wafer W, and can disregard the effect to the optical coat of the underside Pe of a lens element is added at few rate. The methyl alcohol which has a refractive index almost equal to pure water as the additive is desirable. If it does in this way, even if the methyl alcohol component in pure water evaporates and content concentration changes, the advantage that refractive-index change as the whole liquid LQ can be made very small will be acquired.
[0033] Now, although the temperature of Liquid LQ is controlled by fixed precision to a certain target temperature, a current comparison precision which can carry out temperature control easily is about **0.01 degrees C. Then, the realistic immersion projection under such a temperature control precision is considered. general -- the temperature coefficient Na of the refractive index of air -- about -9x10-7/degree C -- it is -- the temperature coefficient Nq of the refractive index of water -- about -- it is -8x10-5/degree C, and the temperature coefficient Nq of the refractive index of water is larger about double figures. On the other hand, when working distance is set to L, amount of wave aberration deltaF of the image formation which originates in amount [of temperature changes (temperature unevenness)] deltaT of the medium which fills

working distance L, and is produced is expressed with a degree type in approximation. deltaF=Land|N|-deltaT [0034] Here, in the usual projection exposure which does not apply immersion projection, amount of wave aberration deltaFair when making 10mm and amount of temperature changes deltaT into 0.01 degrees C is as follows about working distance L. deltaFair=Land|Na|-delta -- amount of wave aberration deltaFlq obtained under the working distance L with T**0.09nm same again and amount of temperature changes deltaT when immersion projection is applied is as follows.

deltaFlq=L, |Nq|, and deltaT**8nm[0035] The greatest amount of wave aberration deltaFmax by which this amount of wave aberration is generally permitted 1/30 of the operating wavelength lambda or 1 / when ArF excimer laser is used since 50 to about 1/100 is made desirable is set to lambda/30, lambda / about 50 to lambda/100 6.43, or 3.86-1.93nm, and is desirably set to lambda/100 of 1.93nm or less. By the way, each thermal conductivity in 0 degree C of air and water serves as 0.0241 W/mK with air, and it becomes 0.561 W/mK with water, and water of heat conduction is better, it can do smaller than it in air, and the temperature unevenness within the optical path formed underwater can also make small fluctuation of the refractive index generated in a liquid as a result. However, as expressed to the formula (3), when working distance L is about 10mm, even if amount of temperature changes deltaT is 0.01 degrees C, amount of wave aberration deltaFlq to generate will exceed amount of permissible aberration deltaFmax greatly.

[0036] Then, the relation of the amount of temperature changes deltaT and working distance L in consideration of amount of allowance wave aberration deltaFmax is set to deltaFmax=lambda/30>=L-|Nq|-deltaT, or delta Fmax=lambda / 100 >=L, |Nq| and deltaT from the above consideration. Here, if amount of temperature changes deltaT assumed is made into 0.01 degrees C and 193nm and refractive-index variation Nq of Liquid LQ are made into -8x10-5/degree C for wavelength lambda, the working distance (thickness of a liquid layer) L needed will be set to 8mm or 2.4mm or less. It is better to make the working distance L smaller than 2mm desirably within limits to which Liquid LQ flows smoothly. While the temperature control of Liquid LQ becomes easy by constituting like this example as mentioned above, degradation of the projection image produced in the wave aberration change resulting from the temperature change in a liquid layer is suppressed, and it becomes possible to carry out projection exposure of the pattern of Reticle R by very high resolving power.

[0037]

[Explanation of the 2nd example] Next, the 2nd example of this invention is explained with reference to drawing 4 . This example shows the temperature control method of the applicable liquid LQ, and operating of the liquid LQ at the time of exchange of Wafer W also like the 1st previous example. Therefore, the same sign is attached to previous drawing 1 and the same thing as the member in three in drawing 4 . Now, two or more adsorption sides 113 are formed in the wafer installation section formed in the inner pars basilaris ossis occipitalis of the holder table WH as a circular crevice in drawing 4 . And the slot 51 used for supply and blowdown of Liquid LQ is formed around the circular wafer installation section annularly, and a part of the slot 51 is connected with the external pipe 53 through the path 52 formed in Table WH. Moreover, the heat regulators 50A and 50B, such as a Peltier device, are embedded directly under [of the wafer installation section in the holder table WH], and directly under the auxiliary plate section HRS, a thermo sensor 55 is attached in the suitable location on the holder table WH (desirably two or more places), and the temperature of Liquid LQ is detected by the precision. And heat regulators 50A and 50B are controlled by the controller 60 so that the temperature of the liquid LQ detected

by the thermo sensor 55 becomes constant value.
[0038] On the other hand, the pipe 53 is connected to the liquid supply unit 64 and the drainage pump 66 through the change bulb 62. The change bulb 62 answers a command from a controller 60, and it operates so that the passage which supplies the liquid LQ from the liquid supply unit 64 to a pipe 53, and the passage which returns the liquid LQ from a pipe 53 to the supply unit 64 through a drainage pump 66 may be changed. Moreover, in the supply unit 64, thermoregulator 64B which maintains at fixed temperature whole liquid LQ in a tank including pump 64A which supplies Liquid LQ, and its pump 64A from the reserve tank (un-illustrating) which can hold the whole liquid LQ on the holder table WH, and this tank is prepared. Furthermore in the above configuration, each actuation of a bulb 62, pump 64A, thermoregulator 64B, and a drainage pump 66 is controlled by the controller 60 in generalization.
[0039] Now, in such a configuration, if Wafer W is laid on two or more adsorption sides 113 in the condition, PURIARAIMENTO [conveyed and] on the installation section of the holder table WH, reduced pressure immobilization will be carried out through the piping 112 for vacuum adsorption shown in drawing 3 . In the meantime, it is being continued by controlling heat regulators 50A and 50B the temperature used as a target. And if vacuum adsorption of Wafer W is completed, the change bulb 62 will change from a closing location to the supply unit 64 side, the liquid LQ by which the temperature control was carried out will be poured in only for a constant rate inside the wall LB of the holder table WH through a pipe 53, a path 52, and a slot 51 by actuation of pump 64A, and the change bulb 62 will return to a closing location. Then, shortly after the exposure to Wafer W is completed, the change bulb 62 changes from a closing location to a drainage-pump 66 side, and is returned in the reserve tank of the supply unit 64 through the liquid LQ fang furrow 51 on Table WH, and a pipe 53 by actuation of a drainage pump 66. Based on the detecting signal from the thermo sensor in a reserve tank, temperature control of it is carried out to a precision by thermoregulator 64B until the liquid LQ returned in the tank can prepare the following wafer.
[0040] Thus, since according to this example temperature control of the liquid LQ under immersion exposure was carried out, Liquids LQ are collected in the supply unit 64 and it was made to carry out temperature control during wafer exchange actuation with the heat regulators 50A and 50B in the holder table WH, while wafer exchange is attained in atmospheric air, there is an advantage referred to as being able to prevent the big temperature change of Liquid LQ. the liquid LQ which is furthermore poured into the holder table WH after wafer exchange according to this example -- even if -- laying temperature -- receiving -- being small (for example, about 0.5 degrees C) -- though it differs, since the depth Hq (refer to drawing 3) of a liquid layer is shallow generally and laying temperature may be reached comparatively early, the time amount which waits for temperature stability may also be shortened.
[0041]
[Explanation of the 3rd example] Next, the 3rd example is explained with reference to drawing 5 . Drawing 5 expresses the partial cross section of the holder table WH which improved the configuration of previous drawing 3 , the holder table WH of this example has separated on the wafer chuck 90 holding Wafer W, and the ZL stage 82 which performs the Z direction migration and tilt migration for focal leveling, and the wafer chuck 90 is laid on the ZL stage 82. And the ZL stage 82 is formed on X-Y stage 34 through three Z actuators 32A and 32C (32B omits). And the paths 53A and 53B connected to Wall LB, the auxiliary plate section HRS, the piping 112 for vacuum adsorption, supply of Liquid LQ, and the pipe 53 (refer to drawing 4) for blowdown are formed in the chuck 90 like drawing 1 , and 3 and 4, respectively. However, path 53A is

connected with the circumference part of the auxiliary plate section HRS of the wafer chuck 90 interior, and path 53B is connected with the lowest part of the wafer installation section of the pars basilaris ossis occipitalis in the wafer chuck 90. Thus, formation of the path for liquid blowdown and the impregnation in the wafer chuck 90 to two or more places performs receipts and payments of a liquid promptly.
[0042] Furthermore, by this example, three breakthroughs (two are illustrated) 91 are formed in the center section of a chuck 90, and three pin center,large rise pins (two are illustrated) 83 which move up and down through this breakthrough 91 are formed on the vertical-movement drive 85. Besides, the downward moving drive 85 is fixed to an X-Y stage 34 side. The three pin center,large rise pins 83 are for only a constant rate lifting the wafer W on a chuck 90 from an installation side at the time of wafer exchange, or taking down Wafer W on an installation side, and where vacuum adsorption of the wafer W is carried out in the installation side of a chuck 90, as shown in drawing 5 , the apical surface of the pin center,large rise pin 83 is set as the location which fell rather than the installation side of a chuck 90.
[0043] On the other hand, it is constituted by the point of projection lens system PL used by this example so that the parallel plate CG of the quartz fixed at right angles to an optical axis AX may be attached at the head of the sub lens-barrel 80, therefore lens element LE1 (plano-convex lens) at a head may not be soaked in Liquid LQ. In this example, spacing of the underside of this parallel plate CG and the front face of Wafer W serves as working distance on appearance, and is set as 2mm or less like a previous example. Moreover, the anchoring side with the parallel plate CG of the sub lens-barrel 80 is waterproofed, and the interior of the sub lens-barrel 80 is filled up with nitrogen gas.
[0044] Thus, if the parallel plate CG is formed at the head of projection lens system PL, even if a substantial back focus distance (distance from the optical element at a head with refractive power to the image surface) of projection lens system PL is about 10-15mm, the immersion projection which working distance L was easily set [projection] to about 1-2mm, and reduced the effect of the temperature change of a liquid is realizable. Moreover, since the parallel plate CG can be formed by post-installation, it becomes possible [correcting easily the local very small distortion aberration (or random distortion) produced within the projection image] by grinding a part of front face of the parallel plate CG to the 1/several about order of wavelength. That is, the parallel plate CG will combine the function as an aperture which protects the latest lens element of projection lens system PL from a liquid, and the function as a distortion compensation plate. In addition, since the image formation engine performance of projection lens system PL including the parallel plate CG is guaranteed if another view is carried out, a change does not have the parallel plate CG in it being the latest optical element of projection lens system PL.
[0045]
[Explanation of the 4th example] Next, the 4th example of this invention is explained with reference to drawing 6 . This example is connected also with the example shown in previous drawing 5 , and is related with the wafer exchange at the time of using the projection optical system which made working distance very small for the immersion projection exposing method. In drawing 6 , the reference mirror ML (the object for the directions of X and for the directions of Y) reflected in response to the beam BSr for reference from the laser interferometer 33 shown in drawing 1 is being fixed to the soffit section of the lens-barrel of projection lens system PL. And the beam BSm for length measurement from a laser interferometer 33 is projected by the migration mirror MRw fixed to the edge of the ZL stage 82 as shown in previous drawing 5 , the reflective beam interferes in a laser interferometer 33 with the reflective beam of return and the

beam BSr for reference, and the coordinate location of the reflector of the migration mirror MRw, i.e., X of Wafer W, and the coordinate location of the direction of Y are measured on the basis of the reference mirror ML. Now, also in this example, the ZL stage 82 is attached on X-Y stage 34 through three Z actuators 32A and 32B (32C omits), and is movable in a Z direction and the direction of a tilt. However, it is combined with X-Y stage 34 through flat springs 84A and 84B (84C omits) by three places of the circumference of it, and the ZL stage 82 is supported so that the rigidity of the horizontal direction (inside of XY side) to X-Y stage 34 may become very large.

[0046] And although the wafer chuck 90 as previous drawing 5 also with the same this example is formed on the ZL stage 82, a different point from drawing 5 is having made it the configuration which boils the wafer chuck 90 comparatively with the drives 88A and 88B of two or more Z directions, and moves to a Z direction to the ZL stage 82 by big stroke (about 10-15mm). unlike Z actuator 32A for focal leveling, and B and C, these drives 88A and 88B move the wafer chuck 90 among the ends of that stroke -- sufficient -- it is good at the easy elevation function using an air cylinder, a link mechanism, etc. Furthermore in the example of drawing 6 , it is fixed, without the pin center,large rise pin 83 shown in previous drawing 5 moving up and down on X-Y stage 34. And after the wafer chuck 90 has gone up most like drawing 6 , the front face of Wafer W was set as about 1-2mm from the field of the optical element at the head of projection lens system PL, and the apical surface of the pin center,large rise pin 83 has fallen to the down side (about 2-3mm) more slightly than the wafer installation side of the wafer chuck 90.

[0047] With the above configurations, drawing 6 will discharge the liquid LQ on the wafer chuck 90 temporarily by blowdown actuation of the liquid LQ shown in previous drawing 4 , if the condition at the time of the exposure actuation to Wafer W is expressed and the exposure actuation is completed. Then, if vacuum adsorption of the wafer chuck 90 is canceled, Drives 88A and 88B will be operated and the wafer chuck 90 will be brought down at the bottom from the location of drawing 6 . While Wafer W is again carried by this on three apical surfaces of the pin center,large rise pin 83, it is positioned so that the upper bed side of the wall LB of the wafer chuck 90 circumference may become lower than the apical surface (the inside of drawing 3 the inside of the underside Pe of lens element LE1, and drawing 5 underside of the parallel plate CG) of projection lens system PL. If X-Y stage 34 is moved to a wafer exchange location in the condition, Wafer W will be pulled out from directly under [of projection lens system PL], and will move to the direction of the arm 95 for conveyance. It is in the condition set as height which becomes lower than the wafer W on the pin center,large rise pin 83 more highly than the upper bed side of the wall LB of the wafer chuck 90 at this time as for an arm 95, and enters into Wafer W bottom. And an arm 90 performs vacuum adsorption, lifting Wafer W slightly upward, and conveys Wafer W towards a predetermined unload location. Carrying in of Wafer W is completely carried out to reverse with the above sequence.

[0048] By the way, since the pool of Liquid LQ spreads out directly under the optical path of a reference beam BSr in the case of a method with which a laser interferometer 33 projects a reference beam BSr on the reference mirror ML of projection lens system PL as shown in drawing 6 , it is possible to give fluctuation to the optical path of a reference beam BSr by lifting of the saturated steam of the liquid LQ. So, in this example, the covering plate 87 is arranged between the optical path of a reference beam BSr, and Liquid LQ, and the fluctuation which intercepts the steamy style which goes up from Liquid LQ, and is generated in the optical path of a reference beam BSr is prevented.

[0049] In addition, the up space of the covering plate 87 may be ventilated in the pure air by which temperature control was carried out in the direction which intersects an optical path, in order to make the optical path of a reference beam BSr stability more. In this case, the covering plate 87 will be equipped also with the function to prevent that the air for optical-path air conditioning is sprayed on the direct liquid LQ, and can reduce unnecessary evaporation of Liquid LQ. Moreover, it may replace with the mere covering plate 87, and the whole optical path of a reference beam BSr may be made a wrap configuration with a windshield tube.

[0050]

[Explanation of the 5th example] Next, the 5th example of this invention is explained with reference to drawing 7 (A) and (B). This example combines the pin center,large rise device (a pin 83, Z actuator 85) shown in drawing 5 with the structure of the holder table WH shown in previous drawing 1 , and it improves the holder table WH so that wafer exchange may be simplified. And drawing 7 (B) expresses the flat surface of the improved holder table WH, and drawing 7 (A) expresses the cross section of 7A view in drawing 7 (B). The holder table WH is held through three Z actuators 32A and 32C (32B omits) on X-Y stage 34, and three breakthroughs 91 are formed near the center of the holder table WH so that the drawing 7 (A) and (B) may show. In this breakthrough 91, the pin center,large rise pin 83 which moves up and down by the actuator 85 passes.

[0051] As explained also in advance, if the height of the lowest end face of projection lens system PL remains as it is, it is separated from the front face of the auxiliary plate section HRS (wafer W) only about 2mm. The upper bed of the wall LB furthermore prepared around the holder table WH is higher than the lowest end face of projection lens system PL. Therefore, when it constitutes so that X-Y stage 34 may be moved as it is for wafer exchange and a wafer may be pulled out from directly under [of projection lens system PL], a part of width of face of the auxiliary plate section HRS will enlarge content volume of the holder table WH on which the diameter dimension extent required next door of the lens-barrel of projection lens system PL and Liquid LQ are poured in.

[0052] So, in this example, as shown in drawing 7 , a part of wall LB of the holder table WH was cut and lacked, and the fluid-tight door section DB which can be opened and closed freely there was formed. While Liquid LQ is poured in, this fluid-tight door section DB has always closed the notching section of Wall LB in the state of fluid-tight, as shown in drawing 7 (A) and (B), and if Liquid LQ is discharged from the holder table WH, it will open it like the broken line in drawing 7 (A). In the condition of having opened, the fluid-tight door section DB is set up so that it may become low a little rather than the height of the front face of the auxiliary plate section HRS. Moreover, O ring OLs (notching section of Wall LB etc.) who ensure fluid-tight nature like drawing 7 (B) are prepared in the proper location at a part for the wall by the side of the holder table WH body which touches the wall of the fluid-tight door section DB.

[0053] In the above configurations, when exchanging the wafer on the holder table WH, after discharging the liquid LQ in the holder table WH first, the fluid-tight door section DB is opened. Then, when X-Y stage 34 is moved to right-hand side in drawing 7 , a wafer will be pulled out from directly under [of projection lens system PL]. Projection lens system PL is located in the headroom of the fluid-tight door section DB opened exactly at this time. And a wafer is easily exchangeable, if the pin center,large rise pin 83 is raised and a wafer is lifted more highly than Wall LB.

[0054] There is an advantage temperature management of Liquid LQ not only becomes easy, but that become possible to make into min the diameter of the wall LB which encloses the perimeter

of the holder table WH according to this example, become possible to stop the total amount of the liquid LQ filled in the holder table WH to the minimum, and the impregnation blowdown time amount of Liquid LQ becomes min. In addition, although it is not necessary at the time of the configuration of said 4th example to prepare the fluid-tight door section especially since a wafer chuck descends, in the configuration of the 4th example, the fluid-tight door section may be prepared still more.
[0055]
[Explanation of the 6th example] Next, drawing 8 shows the 6th example of this invention, and uses the lower container 7 and the up container 8 in this example. Wafer electrode-holder 3a which lays a wafer 3 is formed in the inner surface pars basilaris ossis occipitalis of the lower container 7, the top face of the lower container 7 is sealed by the base of the up container 8, and the complete product of the lower container 7 is thoroughly filled by immersion liquid 7a. Immersion liquid 8a is filled by the another side up container 8, and last lens side 1a of a projection optical system 1 is dipped in the immersion liquid 8a.
[0056] A part of immersion liquid 7a in the lower container 7 is led to a thermoregulator 6 from the exhaust port 5 prepared in one side face of the lower container 7, and in a thermoregulator 6, it circulates through temperature control so that it may return to the lower part [inlet / 4 / which was established in the other side faces of the lower container 7 after the carrier beam] container 7. The thermo sensor (not shown) is attached in two or more [in the lower container 7], and based on the output from a thermo sensor, the thermoregulator 6 is controlled so that the temperature of immersion liquid 7a in the lower container 7 becomes fixed. Moreover, the same temperature regulatory mechanism is prepared also about immersion liquid 8a in the up container 8.
[0057] In this example, the wafer 3 is moved by moving the lower container 7 and the up container 8 as one. On the other hand, since the immersion liquid in the lower container which held the wafer 3 is sealed substantially, it is not only advantageous in respect of temperature stability, but it does not generate the pressure distribution by flow, such as an eddy in an immersion liquid. that is , although the pressure distribution in an immersion liquid serve as fluctuation of a refractive index and it become the factor of image formation wave aberration aggravation , that pressure distribution become a problem in this 6th example be only immersion liquid 8a filled by the up container 8 , and it can ease the effect of the immersion liquid flow of the time of wafer migration by forming the optical path L8 of this part short enough to the level which do not become a problem practically .
[0058] In addition, although the lower container 7 and the up container 8 were moved as one in this example, only the lower container 7 can be moved and the up container 8 can also be fixed. Immersion liquid 8a in the up container 8 will stop thoroughly at the time of this configuration. Therefore, among working distances L, it is desirable to form thinly enough the thickness L7 of immersion liquid 7a in the lower part [thickness / L8 / of immersion liquid 8a in the up container 8] container 7.
[0059]
[Explanation of other modifications] As mentioned above, although each example of this invention was explained, as shown in previous drawing 1 , since the working distance at the time of immersion projection exposure is very as small as about 1-2mm, focusing to Wafer W shall use the focal alignment sensor FAD of an off-axis method. However, the focal detection device of the TTL (SURUZA lens) method which projects the beam for focal detection on a wafer through the periphery within the projection visual field of projection lens system PL, and

measures the height location or inclination on the front face of a wafer may be established as indicated by the U.S. Pat. No. 4,801,977 number, the U.S. Pat. No. 4,383,757 number, etc., for example.

[0060] Moreover, although the focal alignment sensor FAD shown in drawing 1 shall detect the alignment mark on Wafer W optically by the off-axis method, it is good also as an alignment sensor of the TTL method which detects the mark on Wafer W other than the TTR alignment sensor 45 in drawing 1 to which this alignment sensor also detects the mark on Wafer W through Reticle R and projection lens system PL only through projection lens system PL. Furthermore, if it has the projection optical system which carries out projection exposure under an ultraviolet-rays region (wavelength of 400nm or less), this invention can completely be similarly applied, even if it is the aligner of what kind of configuration.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the overall configuration of the scanning projection aligner by the 1st example of this invention.

[Drawing 2] It is a perspective view for explaining the sequence of scan exposure typically.

[Drawing 3] It is the fragmentary sectional view showing the detailed configuration near the projection lens system in drawing 1 .

[Drawing 4] It is the block diagram showing typically the temperature control and the liquid distribution system of a liquid by the 2nd example of this invention.

[Drawing 5] It is the fragmentary sectional view showing the structure the wafer electrode holder by the 3rd example of this invention, and near a projection lens system.

[Drawing 6] It is the fragmentary sectional view showing the structure the wafer electrode holder by the 4th example of this invention, and near a projection lens system.

[Drawing 7] They are the (A) sectional view showing the structure of the holder table by the 5th example of this invention, and the (B) top view.

[Drawing 8] It is the outline sectional view showing the important section of the 6th example of this invention.

[Description of Notations]

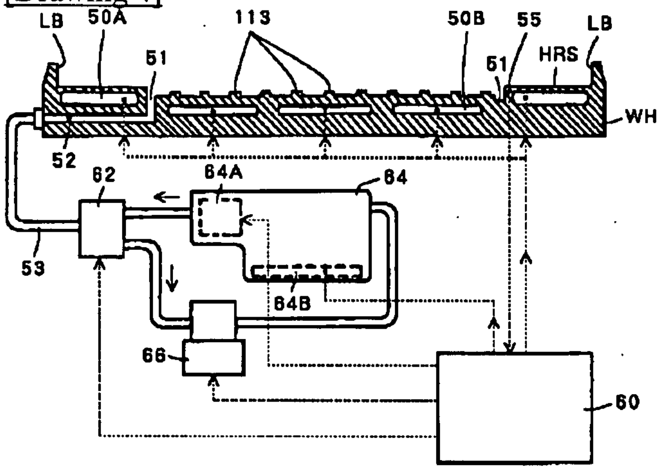
1 -- Projection optical system 1a -- The last lens side
7 Eight -- Container 7a, 8a -- Immersion liquid
3 -- Wafer 3a -- Wafer electrode holder
4 -- Inlet 5 -- Exhaust port
6 -- Temperature controller L -- Working distance
10 -- Illumination system 12 -- Condenser-lens system
14 -- Mirror 16 -- Reticle stage
17 -- Laser interferometer system 18 -- Motor
19 -- Column structure 20 -- Reticle stage controller
30 -- Base surface plate 32A, 32B, 32C -- Actuator

33 -- Laser interferometer system 34 -- X-Y stage
35 -- Wafer stage controller 36 -- Drive motor
40 -- Master controller 50A, 50B -- Heat regulator
51 -- Slot 51 52 -- Path
53 -- Pipe 53A, 53B -- Path
55 -- Thermo sensor 60 -- Controller
62 -- Change bulb 64 -- Liquid supply unit
64A -- Pump 64B -- Thermoregulator
66 -- Drainage pump 66 80 -- Sub lens-barrel
82 -- ZL stage 83 -- Pin center,large rise pin
84A, 84B -- Flat spring 85 -- Vertical-movement drive
87 -- Covering plate 88A, 88B -- Drive
90 -- Wafer chuck 91 -- Breakthrough
95 -- Arm 112 -- Piping
113 -- Adsorption side 114 -- Periphery corner
IL -- Pulse illumination light A.I. Artificial Intelligence -- Lighting field
R -- Reticle Pa -- Circuit pattern space
SB -- Protection-from-light band PL -- Projection lens system
AX -- Optical axis LGa -- Pre-group lens system
LGb -- Rear group lens system Ep -- Exit pupil
LE1 -- Positive lens component Pe -- Underside
CG -- Parallel plate W -- Wafer
SAa, SAb -- Shot field SI -- Projection image
WH -- Holder table LB -- Wall
LQ -- Liquid HRS -- Auxiliary plate section
DB -- Fluid-tight door section OL -- O ring
FAD -- Focal alignment sensor
MRr, MRw -- Migration mirror ML -- Reference mirror
BSr -- Beam for reference BSm -- Beam for length measurement
Sf -- Focal signal Sa -- Alignment signal

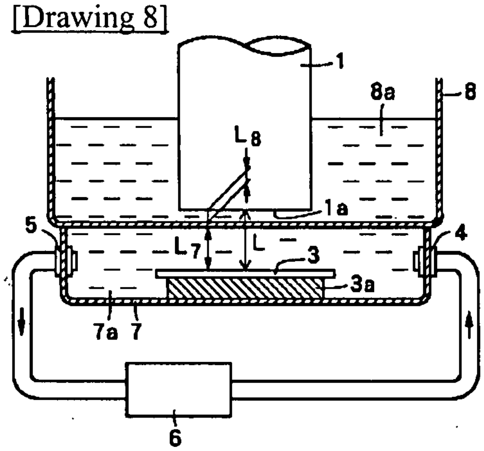
[Translation done.]

DRAWINGS

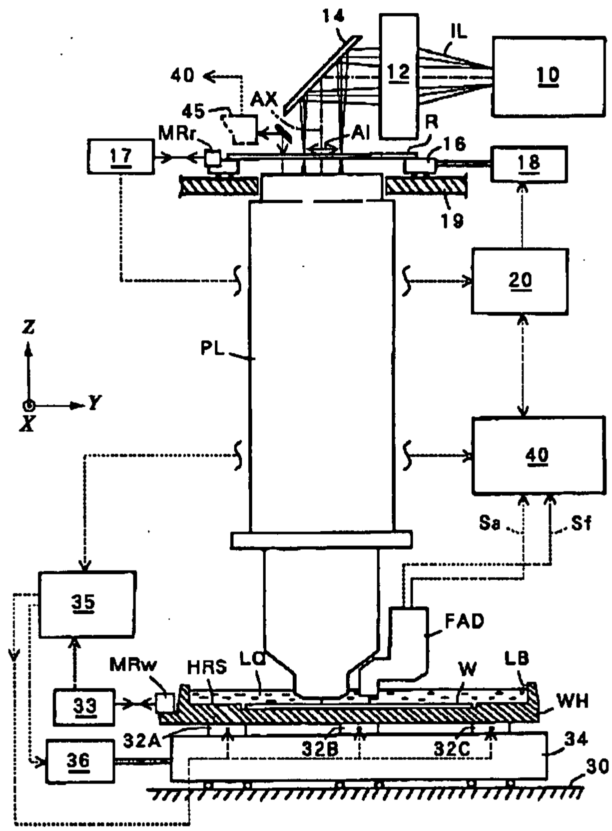
[Drawing 4]



[Drawing 8]



[Drawing 1]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40
45
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AI
R
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17
18
19
20
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X
PL
40
Sa
Sf
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FAD
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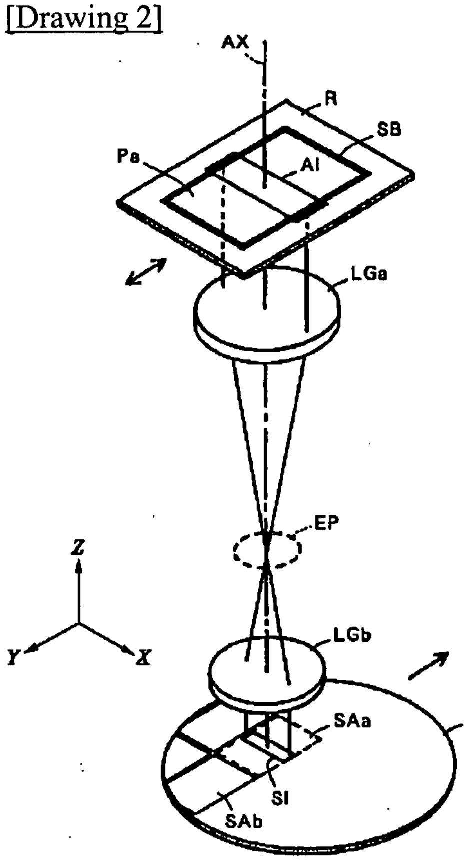
HRS
LQ
W
LB
33
WH
32A
32B
32C
34
36
30

[Drawing 2]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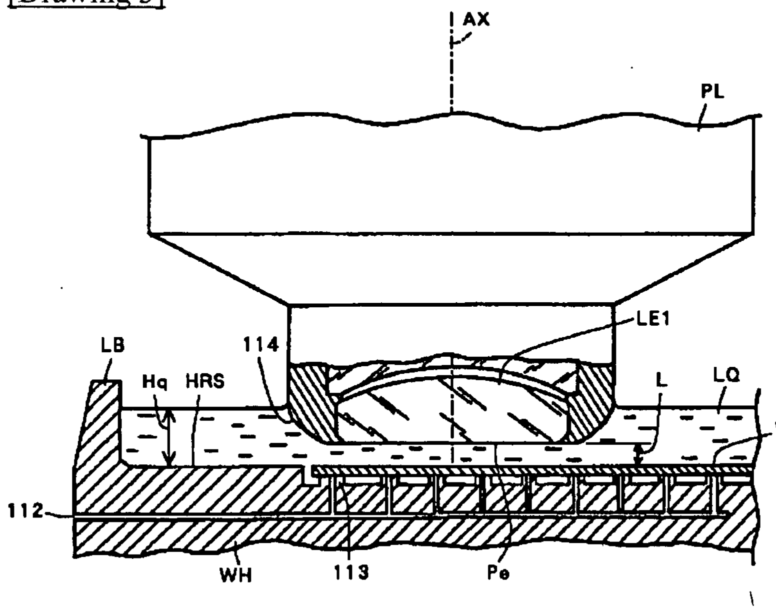
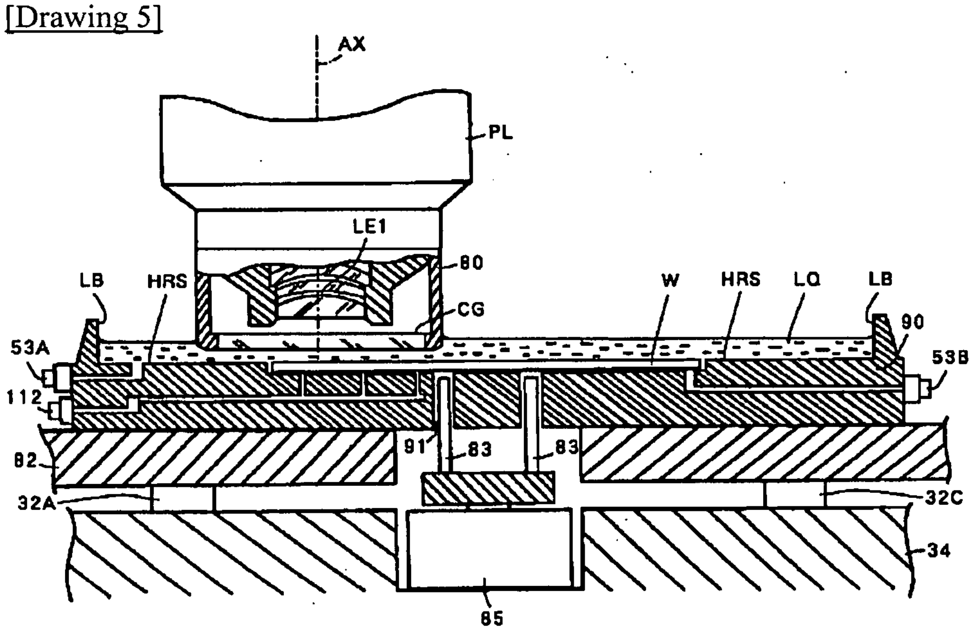
W
SI
SAb

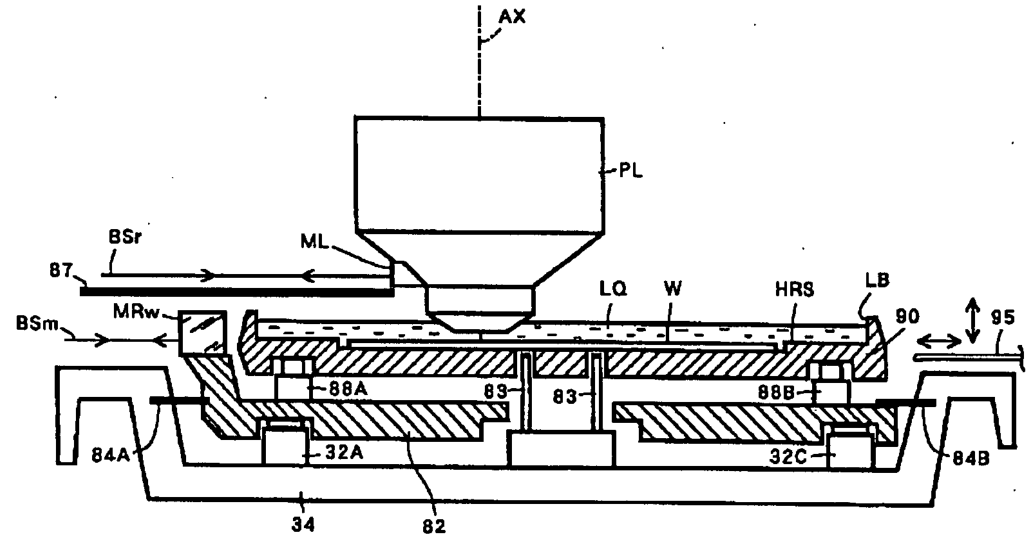
[Drawing 3]



[Drawing 5]



[Drawing 6]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BSr
ML
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LQ
W
HRS
LB
MRw
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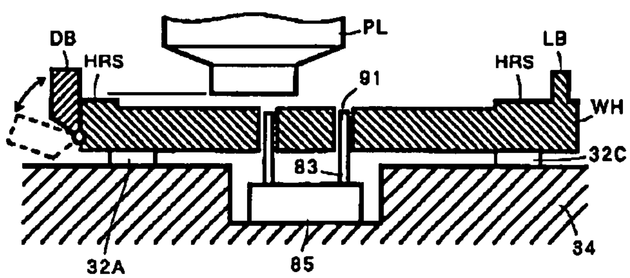
84B
34
82

[Drawing 7]

(A)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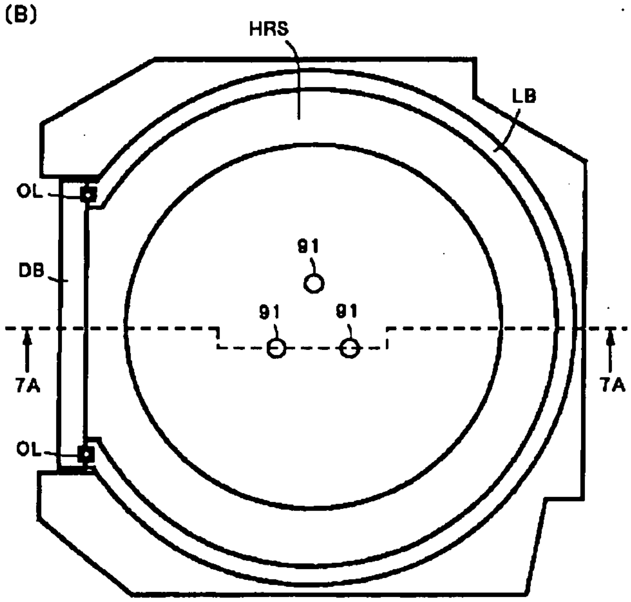
34

(B)


HRS
LB
OL
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DB
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91
7A
7A
OL

[Translation done.]